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ABSTRACT

This course outline, the first volume of a two-volume set, consists of lesson plans for pre-employment laboratory training in general agricultural mechanics. Covered in the 12 lessons included in this volume are selecting tractors and engines, diagnosing engine conditions, servicing electrical systems, servicing cooling systems, servicing fuel and air systems, selecting and using lubricants and filters, servicing air conditioning systems, general servicing, painting power units and farm machinery, servicing and repairing small gasoline engines, setting up and maintaining farm machinery and equipment, and operating welding equipment. Each unit contains suggested procedures and activities, an instructional outline, transparency masters, and a list of references. (MN)

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INSTRUCTIONAL MATERIALS

PRE-EMPLOYMENT LABORATORY TRAINING

GENERAL AGRICULTURAL MECHANICS

(Volume I)

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COURSE OUTLINE FOR LESSON PLANS FOR PRE-EMPLOYMENT LABORATORY TRAINING IN GENERAL AGRICULTURAL MECHANICS
VOLUME I

Unit A	Tractors and Engines	1. Selecting Tractors and Engines
Unit B	Diagnosing Engine Conditions	1. Importance of Engine Maintenance 2. Recommended Methods for Cleaning the Engine 3. Selecting and Using Testing Equipment 4. Selecting and Using Precision Measuring Tools 5. Recognizing Common Troubles
Unit C	Servicing the Electrical System	1. Servicing the Battery 2. Cleaning and Adjusting Spark Plugs 3. Servicing the Distributor and Its Components 4. Ignition Timing 5. Servicing the Generator, Alternator, and Regulator 6. Servicing Starter Motors
Unit D	Servicing Cooling Systems	1. Functions and Service of Different Types of Cooling Systems
Unit E	Servicing Fuel and Air Systems	1. Replacing Lines and Fittings 2. Servicing the Sediment Bowl and Fuel Filters 3. Servicing Air Cleaners and Crankcase Breathers 4. Intake and Exhaust Manifolds and Pipes 5. Checking and Adjusting Gasoline and LP Gas Carburetors 6. Checking and Adjusting Governors 7. Checking and Adjusting Diesel Injector Pumps and Nozzles
Unit F	Lubricating Power	1. Selecting and Using Engine Lubricants and Filters 2. Servicing the Transmission, Differential, and Hydraulic System

		3. Lubricating the Chassis - Cleaning and Lubricating Bearings
Unit G	Servicing An Air Conditioning System	1. Inspecting an Air Conditioning System 2. Adjusting and Testing the System
Unit H	General Servicing	1. Servicing the Clutch 2. Servicing Tires and Wheels 3. Servicing Brakes
Unit I	Painting Power Units and Farm Machinery	1. Cleaning and Painting Farm Machines
Unit J	Servicing and Repairing Small Gasoline Engines	1. Two and Four Stroke Engine Operation 2. Disassembly and Assembly of the Small Engine 3. Checking and Adjusting the Small Engine Carburetor 4. Checking and Adjusting the Governor 5. Checking and Adjusting Valves 6. Checking and Adjusting the Electrical System 7. Inspecting and Repairing the Cylinder and Piston 8. Inspecting and Servicing Engine Lubrication System
Unit K	Setting Up and Maintaining Farm Machinery and Equipment	1. Use of Service and Operator's Manual 2. Some Common Types of Machines, Equipment, and Their Major Parts 3. Inspecting Machines and Equipment 4. Preparing Machinery and Equipment for Storage 5. Selecting and Maintaining Various Belts and Chains
Unit L	Operating Welding Equipment	1. Arc Welding 2. Gas Arc Welding 3. Oxyacetylene Cutting and Welding

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for
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in
GENERAL AGRICULTURAL MECHANICS
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GENERAL AGRICULTURAL MECHANICS

Unit A: Tractors and Engines

Topic 1: Selecting Tractors and Engines

Suggested Procedures and Activities: Charts, transparencies, and slides may be used during the class discussion as aids in explaining differences between gasoline, diesel, and L. P. gas engines. Charts may be used, too, when discussing the different types of tractors.

1. History of the Tractor and Engine

The first successful four stroke cycle internal combustion engine was developed in Germany in 1876. The same year (1876) the first steam traction engine was tested in the United States. Two years later, an Englishman patented a two stroke cycle engine. In 1901 the first gas traction engine was tested. It weighed 20,000 pounds and developed 22 horsepower. A modern tractor that develops 22 horsepower weighs about 3,000 pounds.

Early tractor changes took place during the following years:

1902	Gas traction engines produced commercially
1904	Track-type traction engine introduced
1906-07	The word "tractor" derived from "traction engine" came into use with the founding of the gasoline industry
1908	First gasoline track-type tractor put into use
1919	Farm tractor equipped with power take-off
1920	Starter and lights for tractor
1924	Mounted type tractor equipped with power take-off and the introduction of the general purpose tractor
1931	First diesel engine used on farm tractors and two years later engines produced commercially
1932	Low pressure rubber tires made for tractors

1935	Hydraulic lift equipment installed on tractors
1939	Introduction and use of the three-point hitch
1941	First factory built L. P. gas tractor
1952	Power steering introduced on farm tractors
1959	Introduction of the power shiftable transmission
1967	Hydrostatic transmission introduced

2. Fuel Types of Engines

The three most common fuels used in engines are gasoline, diesel, and L. P. gas. However, natural gas is considered a major fuel in some areas where many stationary engines are used. The major differences between the fuel types are as follows:

a. Method of Supplying and Igniting Fuel - In gasoline engines the fuel and air is mixed in the carburetor and intake manifold; therefore, premixing is outside the combustion chamber. In diesel engines there is no premixing outside the combustion chamber. Air is compressed in the cylinder and fuel is sprayed in just before the piston reaches the top of the compression stroke. The gasoline engine uses the spark from the plug to ignite the fuel mixture, while the diesel engine uses the heat generated by compression to ignite fuel.

b. Higher Compression Ratios in Diesel - Compression ratio compares the volume of air in a cylinder when the piston is at the bottom of the stroke, to the volume of air in the cylinder when the piston is at the top of the compression stroke. An 8 to 1 compression ratio is common for gasoline engines, while a 16 to 1 is normally found in diesel engines. The higher compression ratio thus gives diesel the greater advantage of expansion of gases after ignition with the result of a more powerful power stroke.

c. Design of Engine Parts - Because of the higher compression ratio and the greater expansion of gases following ignition, the diesel engine must be built sturdier at all the places that absorb the shock of combustion. The pistons, cylinders, head, rods, main bearings, and crankshaft are some of the parts that must be "beefed" up.

d. Types of Fuels - Fuel energy is measured in British Thermal Units (BTU) and gives a comparison of power possible from a fuel. Diesel fuel is normally cheaper per gallon. Diesel pumps and injectors are more costly than the gasoline fuel equipment.

e. L. P. Gas Engines - These engines are similar to gasoline engines. The fuel requires special handling. The L. P. gas engine has a higher compression ratio than gasoline but not as high as diesel.

Transparency No. 1

3. Classifying Engines According to Cylinder and Valve Arrangement

   a. The three ways cylinders are arranged in most engines are:

      (1) In-Line - The in-line engines have all cylinders placed in a straight line above the crankshaft. Most of the farm machines use in-line cylinder arrangement.

      (2) V-Type - There are two rows of cylinders above the crankshaft in the V-shape arrangement. Most V-shape engines have either six or eight cylinders. Most of the V-type engines are used in automobiles.

      (3) Opposed - The opposed type cylinder arrangement is made so that two rows of cylinders operate opposite the crankshaft. This type of engine is found in aircrafts and small cars.

   b. The five major ways valves are located in engines include:

      (1) I-Head - The two valves are located at the top of the cylinder and parallel to it.

      (2) T-Head - The two valves are parallel to the cylinder and piston head. They are located on each side of the cylinder.

      (3) H-Head - The H-head is considered the V-block. The valves are located above the cylinders. The valves are parallel to the piston or cylinder head.

      (4) L-Head - The two valves are located on one side of the cylinder. The valves are parallel to the cylinder.

      (5) F-Head - One valve is located at the top of the cylinder and the other is located on one side of the cylinder. Both valves are parallel to the top of the piston.

4. Comparing Engine Performance According to the Fuel Used

	Gasoline	Diesel	L. P. Gas
Continuous use	*C	*B	C
Frequency of Maintenance	C	B	B
Starting When Cold	B	C	C
Use of Fuel	C	*A	B
Acceleration	B	C	B

*A - Best
*B - Good
*C - Fair

Gasoline engines were the most popular type of high compression engines used in farm tractors for many years. However, since larger tractors with more horsepower are used in modern agriculture, tractor manufacturers are making diesel operated machines instead of gasoline and L. P. gas units.

5. Types and Sizes of Tractors

a. The two major types of tractors are: wheel and crawler. Wheel type tractors are most commonly used on farms and ranches. Crawler type tractors may be found on very large farms where they are used to pull heavy machinery, move dirt, and clear land. Many farms use different types of stationary engines and motors in various phases of the farm operation, but the tractor is considered the most essential source of power. It furnishes both mobile and stationary power for crop and livestock production programs, soil conservation practices, land improvement practices, and material handling equipment. Different types and sizes of tractors are made for specific types of farm jobs. Some of the standard types include the following:

(1) Row Crop - This type of tractor is designed for planting and cultivating row crops. It is available with dual front wheels, single front wheel, and wide adjustable front wheels.

(2) Standard Wheel - This tractor is often called the "wheatland" tractor due to its large size. It is suited for open field work.

(3) Utility - This tractor is used for a large variety of row crop jobs. It is considered the right size of tractor for cultivation, mowing, and barnyard work.

(4) Orchard and Grove - The orchard tractor is either the regular wheel type or the track type. It is designed for use in orchards and vineyards.

(5) Lawn and Garden - These small tractors are used around the home, in parks, and on golf courses. They are mainly used for mowing and small cultivation jobs.

(6) Tracklayer - This is considered a heavy duty tractor which is used with heavy equipment on large fields, hillsides, rough land, and for moving soil.

(7) High and Low Clearance - These tractors are either high off the ground for working tall plants or low to the ground for working in confined areas.

b. Tractor sizes may be expressed in the following ways:

(1) Weight - A heavy tractor is usually considered a large tractor for heavy loads.

(2) Horsepower - Tractor engine sizes are also measured by the power to move objects of certain sizes. Power is measured by footpounds per minute. One horsepower is the amount of force that is required to raise 33,000 pounds one foot in one minute. It may be expressed another way: 330 pounds raised 100 feet in one minute expends one horsepower.

$$\text{Horsepower} = \frac{\text{F (Force) x D (Distance)}}{\text{33,000 Ft. Lbs. x 1 minute}}$$

(3) Implement Capacity - The capacity of a tractor may be expressed by how many disks or moldboard bottoms it can pull or the number of rows covered (planted, cultivated, and harvested) by the equipment. For example, an 8 to 12 Hp can pull one 12 inch moldboard plow. An 80 to 130 Hp engine is used to pull six 16 inch moldboard plows.

c. Tractors may also be classed according to their drive system. There are two and four wheel drive tractors. Crop and standard tractors are two-wheel drive.

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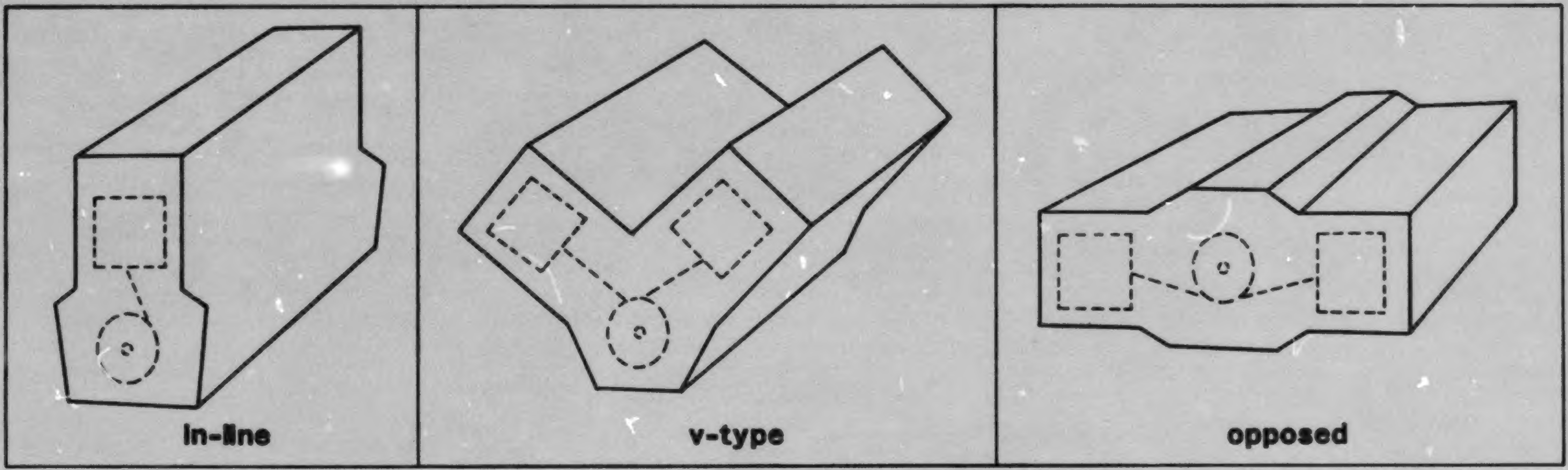
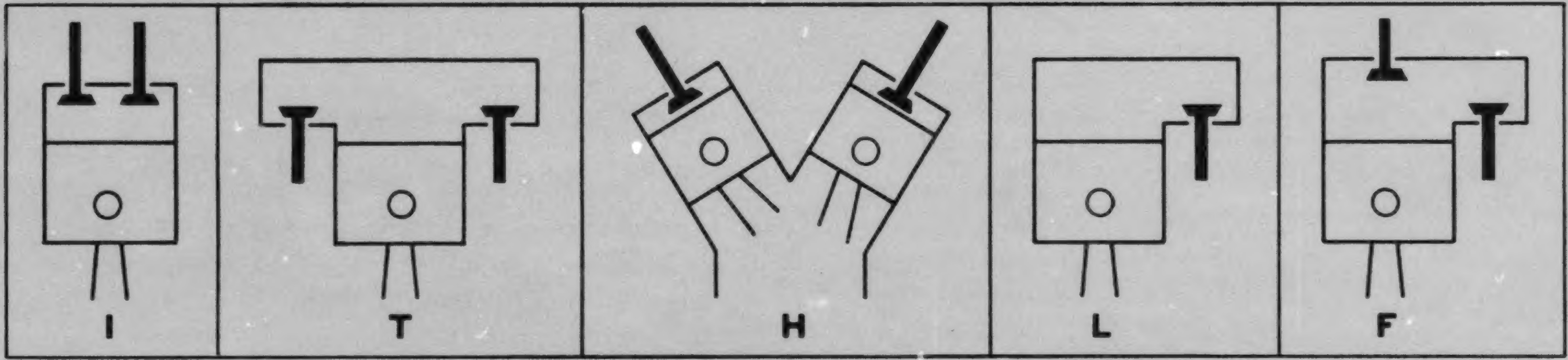
TYPES OF ENGINES


in-line
v-type
opposed

CYLINDER LOCATION IN BLOCK



VALVE LOCATION – TYPE OF HEAD

GENERAL AGRICULTURAL MECHANICS

Unit B: Diagnosing Engine and Engine System Conditions

Topic 1: Importance of Engine Maintenance

Suggested Procedures and Activities: Use a lubrication interval chart and tractor diagram to locate points of lubrication during the class discussion. Use a tractor in the lab to point out these important lubrication points on the engine.

1. Maintaining Engine Systems

   a. The engine is made up of five major operational systems. Without the efficient function of each system, the engine cannot be an efficient heat converter. These systems are: fuel, ignition, electrical, lubrication, and cooling. Maintenance goes beyond just greasing and lubricating squeaking parts. Parts should be lubricated before they begin to squeak and a coolant should be added before it reaches a dangerously low level. Engines are planned and developed to give proper service on many different types of farm machines and usually maintenance practices involve not only the engine but also the entire machine.

   b. Good maintenance practices will eliminate or reduce costly breakdowns at the time when the machine is needed most. Planting and harvesting season may be considered very critical due to weather conditions; therefore, a breakdown could be very costly. Operating cost can be reduced and the horsepower improved if the engine systems are maintained in good condition. For example, tests have proven that about half the power of a tractor is used to make the wheels roll and prevent wheel slippage; therefore, that would leave 20 hp for a drawbar pull using a 40 hp tractor. A 40 hp tractor in poor condition may be rated only at 20 hp. This would leave 10 hp drawbar rating.

2. Tractor Engine Maintenance

   a. A tractor engine is designed to give long and satisfactory service if it receives proper care throughout its useful life. Many tractor engines remain in operation for a period of twenty-five years or even longer due to being operated under a sound maintenance program. This type of program involves daily care. Most operators refer to the operator's manual to determine how often systems and parts need checking. The manual may point out maintenance practices that should be observed at the beginning or close of each day.

b. The tractor manufacturer provides instructions, instruments, and gauges to protect the machine while it is in operation. These devices identify troubles that appear in vital parts of the engine. The instruments and gauges relay messages, and a competent operator watches them while driving the tractor. The gauges and their functions are:

Transparency No. 1

(1) Heat Indicator - This gauge indicates the temperature of the liquid in the cooling system.

(2) Oil Gauge - This dial indicates the oil pressure which is regulated by the circulation of the oil.

(3) Ammeter - This dial points out any trouble in the circuits. It gives the amount of current flowing from the battery.

(4) Hour Meter - Most tractors are equipped with meters which indicate the number of hours of use.

Tractor engines are provided with special air cleaners, guards, bearings, grease fittings, seals, filters, and many special devices to make it one of the most protected engines in operation. Yet, many are disabled or destroyed through unnecessary wear, mechanical troubles, lack of care, and plain crack-ups.

c. New or overhauled tractor engines require a different kind of daily care than those that have been in operation for several months. Some important practices that are observed are:

(1) A new or overhauled tractor engine is operated at less than one-half load at full throttle for the first ten hour period. For the second ten hours, it is operated at one-half load. The new or overhauled tractor should be operated at about one-half load for five to six ten hour periods before operating at a full load.

(2) The engine on a new or overhauled tractor should not be idled for a long period of time. Damage may occur to the cylinder walls or rings due to insufficient lubrication. A corrected fast idle speed should eliminate overspeeding of the engine. A new or overhauled engine should not be overspeeded.

(3) Before a tractor engine is put under a full load, it should be allowed to warm-up. The warm-up period is most important if there is a high moisture content in the air or if the weather is very cold. Even during warm weather, it is advisable to idle the engine a few minutes before operating the tractor at a full load. Much of the engine wear occurs between the time the engine is started and the time it reaches the proper operating temperature. It may take the tractor twenty to thirty minutes to reach a proper operating temperature of 180^{o} to 190^{o}.

(4) Before stopping or shutting off a hot engine that has been pulling a heavy load, it should be allowed to run at idle speed for a few minutes, then turn off the ignition switch.

3. Advantages of a Proper Maintenance Program

   a. Engine operates at higher horsepower and burns less fuel. There can be a 10 percent increase in hp and 15 percent less fuel consumption.

   b. Breakdowns are avoided or reduced in number throughout the life of the engine.

   c. Less chance of a machine breakdown during planting and harvesting seasons and more assurance of engine operation during crop irrigation season.

   d. Major repair cost is usually reduced and time is saved on repair jobs.

   e. Engine operating life is much longer.

   f. The equipment or machine is much safer to operate when the engine is functioning properly.

   g. An operator becomes more familiar with the engine, especially if records are kept and the operator's manual used.

   h. Regular service intervals are established and the habit of putting things off may be eliminated. Also such habits are formed as making a daily maintenance check and watching the instrument panel while the engine is running.

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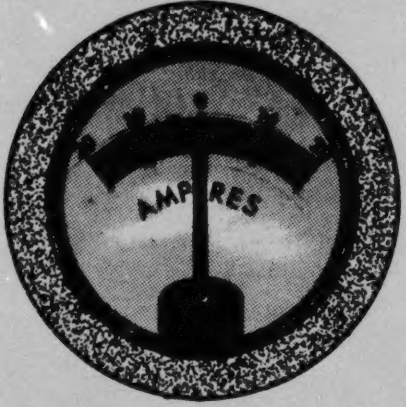
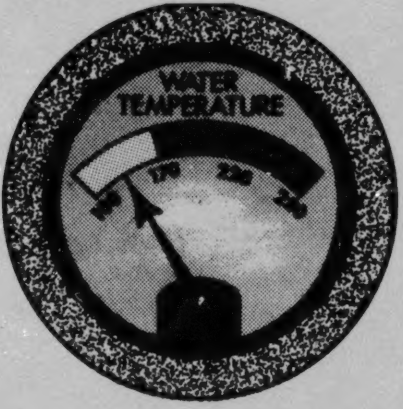
GAUGES TO AID IN OPERATION

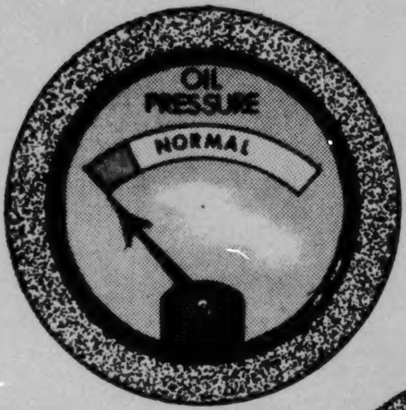
AMPERES GAUGE



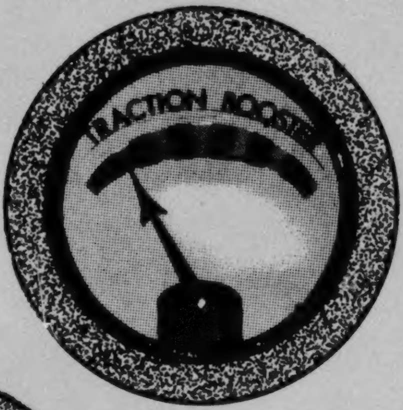
WATER TEMPERATURE GAUGE

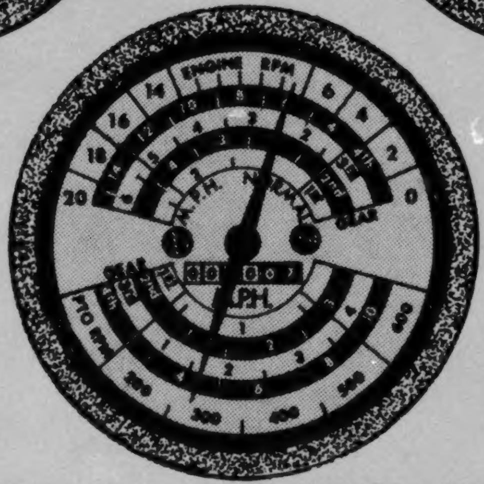

WATER TEMPERATURE
170
220

OIL PRESSURE GAUGE


OIL PRESSURE
NORMAL

TRACTION BOOSTER GAUGE


TRACTION BOOSTER


ENGINE RPM
M.P.H.
NORMAL
PTO RPM
200
300
400
500
600

MILES PER HOUR AND HOUR USE GAUGE

GENERAL AGRICULTURAL MECHANICS

Unit B: Diagnosing Engine and Engine System Conditions

Topic 2: Recommended Methods for Cleaning the Engine

Suggested Procedures and Activities: First observe transparencies on cleaning engine and engine parts, then observe a tractor engine before it is cleaned and discuss the best method to use in cleaning all parts on the outside of the engine.

1. The Meaning of Cleaning

   a. Cleaning is the removal of various forms of soil, sand, grease, oil, tar stains, and many types of film. Most forms of dirt can be removed by washing, sweeping, and shoveling. When mechanics is applied to a cleaning operation, water under pressure, vacuum, and power brushes are used.

   b. There are three types of dirt found on most engine surfaces. They are:

      (1) Loose Dirt - Usually loose dirt can be removed by water under pressure, vacuum, and power brushes.

      (2) Adherent Dirt - The removal of adherent dirt requires the use of heat and a type of solvent or detergent or both in addition to using brushes with water.

      (3) Invisible Dirt - This type of dirt is removed by suitable heat, chemicals, or a combination of the two. Invisible dirt must be removed from an engine before it is painted.

   c. Cleaning or removing adherent dirt requires a factor balance of four factors. For example, the best way to remove dirt from the hands is to use warm (heat) water, soap, and friction. When soap is applied with warm or hot water, the hands rubbed, the surface tension is broken releasing the dirt. If grease is present, an emulsifying action takes place (soap particles surround a particle of grease and move it away). If a soap containing alkali is used to remove animal fats or vegetable oils, a chemical reaction (saponification) takes place. Free alkali combines with the fat, forming a soap. The four basic factors used in steam cleaning are:

(1) Soap - The amount of soap used to clean an engine or machine is regulated by the form and amount of dirt present; therefore, soap can be considered a variable factor used for cleaning.

(2) Heat - Heat actually increases the power of soap. Various surfaces require different temperatures.

(3) Water - Soap and heat are carried to the dirty areas by water. Dirt and soap are removed by the water.

(4) Friction - When washing the hands, they are rubbed together causing some friction. The use of a brush or abrasive power will cause even more friction. When cleaning an engine, friction may be caused by pressure or force.

2. Importance of Proper Cleaning

a. Proper cleaning of a machine and its parts adjacent to the engine is one of the most important jobs that can be performed while repairing or overhauling the engine. Improper cleaning usually means an improper overhaul or repair job. If the engine and its outside parts are to be painted, the surface must be clean in order for the paint to adhere to it.

b. Precleaning or cleaning before the engine is disassembled is absolutely necessary to prevent contamination of parts during the teardown. After the engine is dismantled the parts can be cleaned.

c. It is true that a dirty engine may show oil and water leaks before it is cleaned, but it is easier to pin point these areas if the engine is clean. For example, leaking core plugs or cracks on a diesel engine may be located by rust leaks. These rust areas cannot be found on a very dirty head and engine block.

d. Reconditioned or new engine parts should never be replaced on dirty greasy parts. Such parts may become contaminated immediately after installation or fail to fit snug even though gaskets are used.

Transparencies Nos. 1 and 2

3. Clean Methods

a. Steam Cleaners - Steam cleaners were the first cleaners used to clean engines and machine parts. A steam unit consists of a heat unit (oil or gas) that forces heat through a number of coils generating steam pressure from the water, flexible steam hose, and a steam gun. In some units the cleaning solution is fed directly to the gun, whereas in other units it is mixed in the cleaning solution. Steam without a steam cleaning compound is a hot, soft, gasified fluid lacking mass. It is similar to a sand blast stream without the sand. It is used in the following manner:

(1) The water and water pump are turned on to fill the coils with water. This step is followed by igniting the burner.

(2) The solution tank is checked and stirred, or steam pressure is forced into the solution by the gun.

(3) Cleaning solutions may damage the carburetor, generator or alternator, and distributor; therefore, these areas should be covered or protected during the cleaning process.

(4) Prolonged steaming should be avoided in and near the electrical system. And, it is recommended that air conditioning lines not be steamed.

(5) Usually a gun nozzle is held one to four inches from the object being steamed. A "wet" or "watery" steam is recommended for cleaning.

(6) Safety rules to observe when steam cleaning are:

(a) Work must be well ventilated.
(b) Steam cleaner should be grounded.
(c) Pressure should be in proper limits and the work area free of personnel.
(d) Face shield should be worn to protect face and eyes from splatters.
(e) Directions in the instruction book should be followed when operating the machine.

b. Hot Tank Cleaner - Hot tanks are used for heavy cleaning. A strong alkaline compound is usually mixed with water and the solution heated from 180 to over 200 degrees F. If aluminum parts are cleaned in the hot tank, the caustic solution should be weakened. After all parts are taken from the tank, they should be washed thoroughly. Parts that may rust must be oiled. Any part that may contain the solution, such as water jackets or oil galleries, should be thoroughly flushed out with hot water. The most commonly used cleaner compound for hot tank cleaning is a detergent.

c. Pressure Spray Cleaning - The two types of pressure cleaning are high (up to 500 pounds per square inch) and low which requires a small amount of pressure. Both methods (high and low pressure) require that a soft mist of detergent or other cleaning solvent be sprayed on the object as the first cleaning step. After dirt deposits soften, the high pressure gun may be used to remove dirt using a fan shape stream of water and adjusting to a narrow stream at high velocity for removing dirt in corners. The low pressure gun is usually used to spray a solvent (kerosene, detergent, or other nonflammable solvent) on the object and it is later washed with water. Even though high pressure cleaning may be done with cold water, some manufacturers have models with a heating coil so that water may be heated to about 160 degrees F.

d. Cold Soak Cleaning - A cold soak tank is usually used to soak parts. The parts are placed in a container (basket) and soaked for several minutes before they are removed and rinsed with a solvent or water. It may be necessary to dry the parts with an air gun, but most of the time they are wiped dry or allowed to dry after rinsing.

e. Ultrasonic Cleaning - This cleaning method is considered new. A generator is used to convert the electric current into electric energy which has a high acoustical frequency. The unit is equipped with a transducer that makes a conversion of electric energy to mechanical energy. The high frequency sound waves form partial vacuums in the cleaning liquid which is moving very swiftly by agitation. Dirt particles are removed by the cavitation blasts.

f. Special Parts Washer - A cold solution parts washer is a much more efficient way to clean parts than washing and soaking them in buckets or cans. Most washers are equipped with trays, solvent agitator, and filters mounted in the tank of the washer. Parts are placed in the trays (baskets) and submerged below the cleaning solution level. This solution is agitated as air is forced through it. Some tanks are equipped with extra tank compartments for brushing, rinsing, and draining. Parts may be allowed to dry or blown dry.

g. Wire Brush and Scraper - Wire brushes and scrapers are used mainly to remove hard carbon deposits on piston heads, valves, grooves, corners, and combustion chambers. Dry cleaning is followed by washing the parts in a solvent and blowing dry. Power brushes are not recommended for cleaning soft parts.

h. Vapor Cleaning - Cleaning is accomplished by heating a nonflammable solution (Perchlorethylene) so that vapors settling on the parts from the solution will cause dirt to be released from the parts. The parts are suspended in metal baskets.

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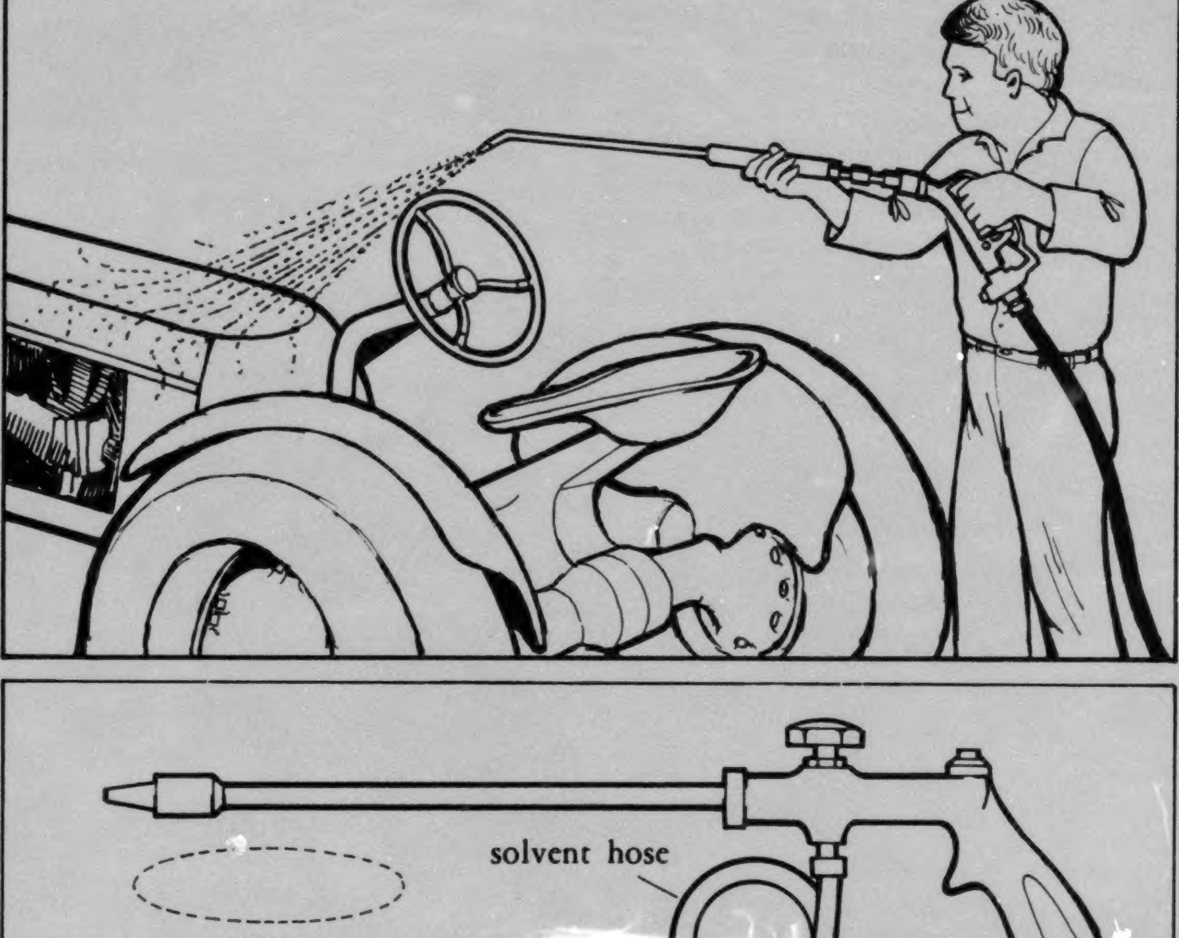
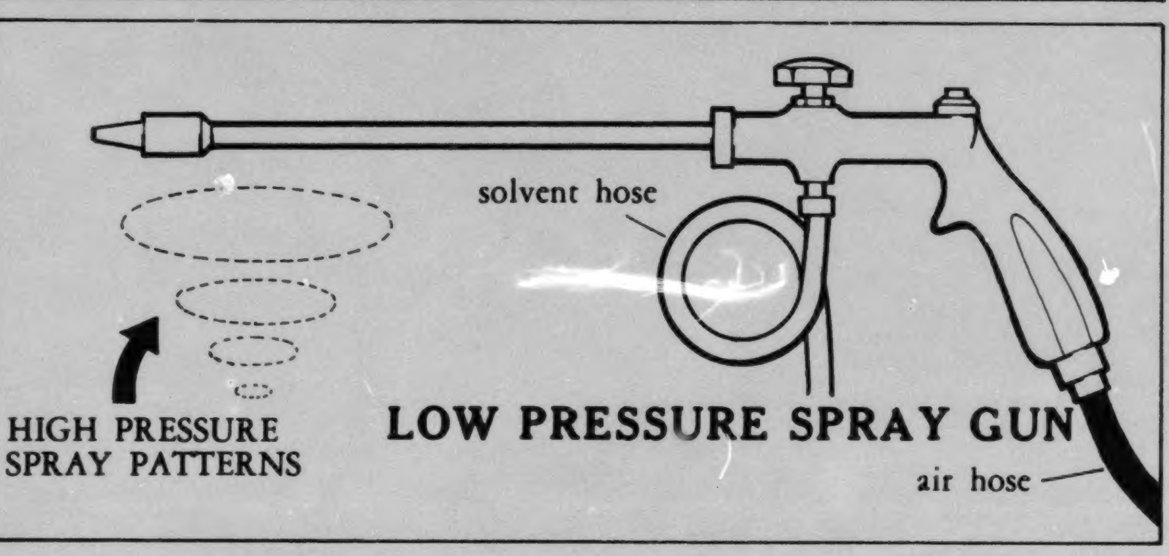
1. Stockel, Martin W., Auto Service and Repair, The Goodheart-Willcox Company, Inc., South Holland, Illinois, 1974

2. Toboldt, William K., Diesel - Fundamentals, Service, Repair, The Goodheart-Willcox Company, Inc., South Holland, Illinois, 1973

CLEANING METHODS

STEAM CLEANING BEFORE TEARDOWN

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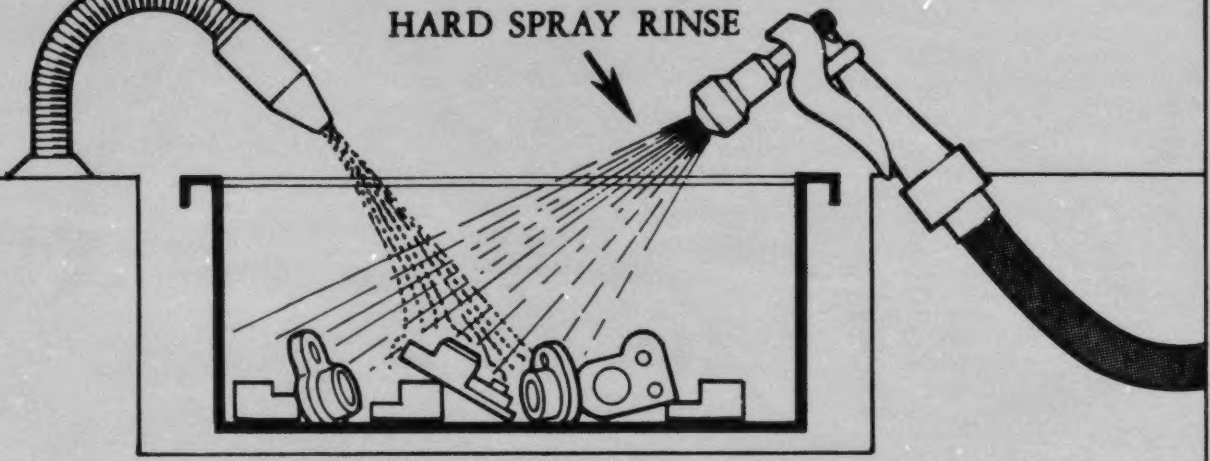
SPRAY PATTERNS
LOW PRESSURE SPRAY GUN
air hose

CLEANING METHODS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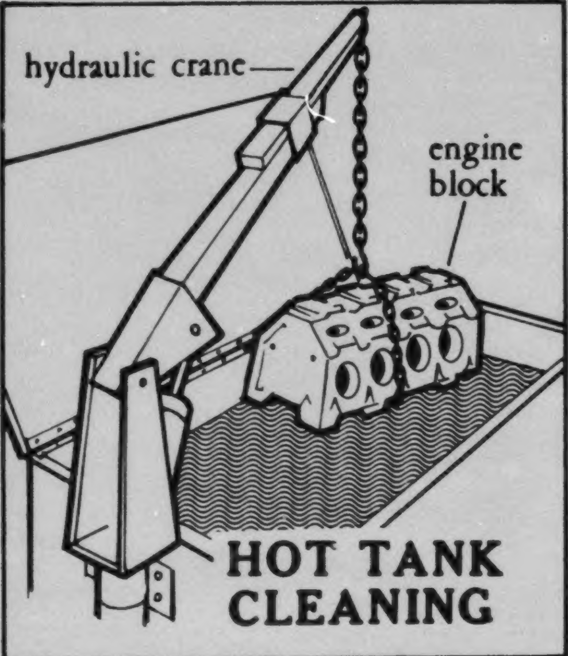
RINSING PARTS WITH FILTERED SOLVENT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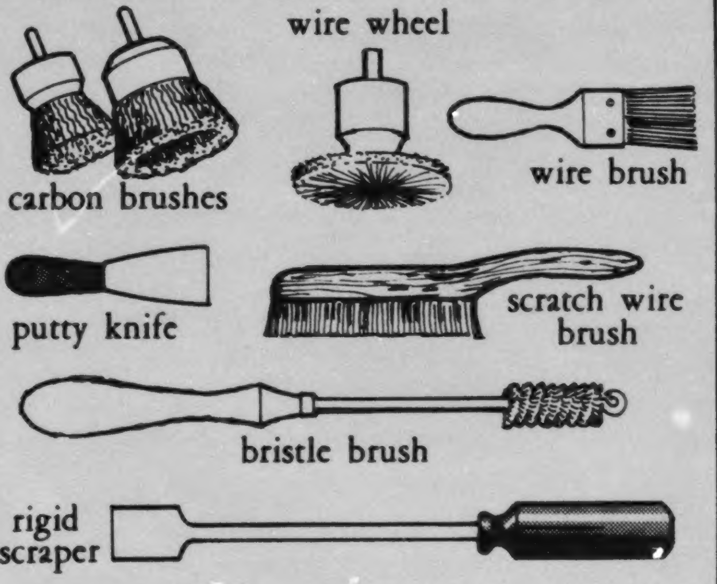
engine block

HOT TANK CLEANING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wire brush
putty knife
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bristle brush
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CLEANING TOOLS

GENERAL AGRICULTURAL MECHANICS

Unit B: Diagnosing Engine and Engine System Conditions

Topic 3: Selecting and Using Testing Equipment

Suggested Procedures and Activities: A display of various types of testing tools and equipment may be helpful during the class discussion. Transparencies can also be used during the discussion of testing equipment.

1. Importance of Testing Tools and Equipment and Selecting According to Use

   a. Engine starting and performance is based upon the proper function of all parts. To determine the malfunction of an engine, testing equipment is used in the four main systems. It is true that some problems can be detected through the use of simple trouble shooting practices. Such practices as listening to an operating engine, driving the vehicle, stopping and starting the engine, accelerating and letting the engine operate at an idle speed may be helpful in determining engine problems, but the size and extent of the problem is determined by the use of testing equipment and precision measuring tools. Many pieces of electrical and ignition testing equipment are known as analyzers. As many as 30 precision tests may be performed on one analyzer.

   b. Precision measuring tools may vary in size from a simple steel rule to an electronic engine tester that is equipped with several testing instruments in one cabinet or a special machine to test diesel injection nozzles. Most testing equipment can be found in a single unit hand-held type such as a compression gauge, vacuum gauge, tachometer, and various dial indicators. A cabinet of instruments is very expensive and owned by large repair shops. The small hand-held gauges and precision tools are usually more practical for a tractor owner and operator.

2. Types of Testing Equipment Used on Engines

Transparency No. 1

   a. Compression Tester - A pressure gauge (compression gauge) is used to check the pounds of pressure in the engine cylinders. Poor engine performance and the lack of horsepower can be due to the lack of compression. Steps used in testing engine compression are:

(1) After the engine reaches operating temperature, remove the spark plugs or injection nozzles and insert a pressure gauge in one of the cylinder ports.

(2) Open the choke valve and carburetor throttle and remove coil- to-distributor wire from the distributor. Ground the loose end by laying it against the engine. This step is used on spark-ignition engines. There is no throttle valve on the air intake system of a diesel engines; therefore, the engine speed control is adjusted to the stop position.

(3) Turn the engine at starting speed using the starter and count the compression strokes if possible so that approximately the same number of strokes will be used on each cylinder. The engine is turned until there is no further rise in pressure. Each cylinder is tested in the same manner.

(4) Apply a small amount of oil through the ports if the compression reading is very low. If some cylinders read lower pressure than others, the variation should not exceed 10 percent.

Transparency No. 1

b. Dwell-Tachometer - The dwell-tachometer is also referred to as a tach-dwell meter or analyzer in that it may be used for more than one type of test. Dwell is the cam angle which is the degrees the breaker cam turns after the breaker points close and they open again. A tachometer gives the speed of an engine in rpm. There are several types of dwell-tachometers, and most are adaptable to several uses. For example, one type may show revolutions per minute on two scales ranging from 0 to 5000 rpm and a low reading from 0 to 1000 rpm. This type may have three dwell angle readings; 8 cylinder, 6 cylinder, and 4 cylinder engines. Degrees dwell varies according to the number of cylinders in the engine. One type of dwell-tachometer may be used in the following manner to make adjustments:

Use	Dwell-Tachometer Lead Connections
Indicates effect point setting without removing distributor cap.	One lead to position on ignition coil and one lead engine ground.
Indicates correct settings for external type distributors.	Same

Indicates proper reading on tach section for best engine performance.	Same
Indicates incorrect point setting caused by worn rubbing block or worn points.	Same
Indicates the average dwell as well as the individual dwell on dual breaker point distributor.	One lead connected to distributor at primary wire from coil connection and the other grounded.
Indicates malfunction of a particular plug causing engine to misfire.	Same
Indicates correct reading on tachometer scale to adjust throttle pressure on automatic transmission with the aid of a pressure gauge.	One lead to distributor point terminal and the other grounded.
Indicates correct tach reading to adjust voltage regulators at specified engine rpm.	Same

Transparency No. 1

c. Vacuum Gauge - A vacuum gauge's main function is to indicate the amount of suction or vacuum in the cylinders. An air flow restriction will cause oil to be drawn in around the valve stems and pistons which increases the consumption of oil. If the problem is not eliminated by cleaning or replacing air cleaners, then a vacuum test may be used. The procedure in making the test is as follows for diesel and spark-ignition engines:

(1) When testing a diesel engine, operate it until the engine is warm, then connect the vacuum gauge to the manifold. Operate the engine at fast idle to take the reading. A high reading means there is a restriction in the air intake system. The technical manual gives the correct specifications.

(2) When testing a spark-ignition engine, use a vacuum gauge with a scale in inches of mercury. After the vacuum gauge is connected to the intake manifold, warm the engine by operating at idle speed and take the reading. This test is known as the manifold depression test. The reading can indicate the loss of power due to late ignition, lack of proper valve timing,

loss of compression, or a leaky carburetor. If the gauge reading drops slowly at an idle speed, there may be a restriction which causes back pressure in the exhaust system. Even though an air cleaner may be the most common type of restriction, there are other problems that cause the malfunction.

d. Dynamometer - A dynamometer measures horsepower of an engine. The three types commonly used on power take-offs are: prony brake, water brake, and gear pump. Dynamometer units are equipped with such dials as a pressure-horsepower gauge, and tachometer. The gear pump unit will have a heat indicator and pump valve. A tractor engine's horsepower is measured by connecting the dynamometer to the power take-off. A truck engine's horsepower may be measured by parking it on a dynamometer and the rear wheels resting on rollers. It is connected to an analyzer for the necessary readings. The dynamometer test on a tractor engine is made in the following manner:

(1) Connect the tractor to the dynamometer. The power take-off on the tractor is used for this purpose. Small tractors usually have a PTO rpm of 540 and large tractors have a 1000 PTO rpm.

(2) Operate the engine for about 30 minutes at one-half load to bring the crankcase oil and coolant to operating temperature.

(3) Use the technical manual to determine the rated load speed and increase the load until the engine speed reaches the rated load. At this point the horsepower is read on the dynamometer. The technical manual is used again to make a comparison between the dynamometer and manual figures.

Transparency No. 2

(4) To determine horsepower use $HP = \frac{\text{Force x Distance}}{\text{Time x 33,000}}$. But to determine horsepower from rotating power a different formula is used. Example, $HP = \frac{\text{Torque (lb.-ft.) x RPM (speed of shaft)}}{5252}$. Torque is the units of force x distance, expressed in lb.-ft. It is the force exerted on an object causing it to turn or rotate. A power test may be stated as follows:

$T = 15 \text{ lbs.} \times 3 \text{ ft.}$
$T = 45 \text{ lbs.}$
$HP = 45 \text{ lb.-ft.} \times 1000 \text{ RPM}$
$HP = \frac{45,000}{5252}$
$HP = 8.5$

An engine cannot develop a good horsepower rating unless there is a supply of clean fuel and air and correct timing of valves and ignition to give proper combustion and proper compression.

Transparency No. 2

e. Fuel Pump Tester - Testing the fuel pump on a spark-ignition engine can be a simple operation if proper equipment is available. There are three tests that can be performed on this type of fuel pump. Diesel fuel pump tests are mainly for making adjustments.

(1) Pressure test is made by disconnecting the fuel line at the carburetor and installing a pressure gauge in the carburetor fuel line inlet. If the gauge connection is mounted to the carburetor by a small hose, it should not be more than 6 inches below or above the carburetor to get a correct reading. On this type of test the flow volume hose is placed in a container and the flow is shut off before the engine is in operation. The second hose is attached to the fuel pump line. When the engine reaches 500 rpm, the shutoff is opened and 4 ounces of fuel is forced into the container venting the pump. Empty the container with the engine stopped, replace the hose in the container, operate the engine at 500 rpm and take a pressure reading. Some engines operate at 4 to 6 psi. There is another type test where the pressure gauge is connected directly to the fuel line after it is disconnected from the carburetor. The carburetor fuel bowl contains enough fuel to operate the engine until a reading can be taken.

(2) Using this same testing gauge, open the shutoff and draw 4 ounces of fuel into the plastic or glass container and record the number of seconds it takes to draw the fuel. The engine is idling at 500 rpm. Place the tube in the fuel and observe for air bubbles with the engine operating and fuel continuing to be drawn into the container. Stop the engine and close the shutoff as soon as 1 pint of fuel is drawn. Continue to keep the time in seconds. The flow will equal 1 quart in one minute or 1 pint in 30 seconds in some engines. This is known as the volume test.

(3) To test the fuel pump inlet vacuum, the tester is connected on the flex line where the gas tank line is connected. Disconnect the line (pressure) at the carburetor. Operate the engine in the same way as for other tests and take a reading. Stop the engine and check the vacuum. Usually the pump is defective if the reading falls rapidly. In some engines, if the reading is 10 inches or more of mercury the bowl, gasket, diaphragm, valves, and flex line are airtight.

(4) To test a diesel fuel pump for suction restriction or vacuum, connect the vacuum gauge to the fuel supply line. Corrections should be made if the vacuum reading exceeds 8 inches of mercury. The fuel manifold pressure should be tested at this point. Use a manifold pressure gauge by connecting it to the pressure gauge connection. The manifold pressure is checked at rated speed (manufacturer's recommended revolutions per minute at crankshaft) and full-load.

f. Oil Pressure Gauge - The oil pressure gauge is found on the engine console, and it should be observed frequently while the engine is operating. The oil pressure should remain normal if the engine is functioning properly with the proper weight of oil. After checking the oil level in the crankcase and condition of the filter and if both seem normal then an oil master gauge should be used to check the oil pressure if the engine is operating at low pressure. The following steps are used:

(1) Connect the master gauge in the special tapped hole for checking pressure if the engine has this type of opening. Otherwise, disconnect the oil pressure sending line and connect the gauge at this point.

(2) Start and operate the engine until it is warm, then operate at fast idle to take the reading.

(3) Compare the recorded reading that is listed in the technical manual.

(4) If the engine is equipped with an adjusting screw, turn the screw to increase or decrease the pressure. Usually turning the screw in gives more tension on the spring and increases the pressure reading. Shims added to the screw will cause more tension on the spring.

Transparency No. 3

g. Battery Tester - The specific gravity of the battery electrolyte is checked with a hydrometer. Steps to follow when using the hydrometer are:

(1) Check the electrolyte level in each cell before checking the specific gravity. If water must be added in order to draw the electrolyte into the hydrometer, charge the battery or operate the engine for several hours to mix the water and electrolyte.

(2) Check each cell by releasing the squeezed bulb and drawing in enough electrolyte to suspend the float. The tube must be held in a vertical position so that the float will ride free in the barrel. A battery is

not usually recharged until it is reduced to less than 75 percent charged or the float reading is below the 1.215 to 1.230 range. A fully charged battery has a specific gravity reading of 1.260 to 1.280.

(3) Take the float reading when the temperature is about 80 degrees F. Four gravity points (0.004) are added for each 10 degrees above 80 degrees F. and four are subtracted for each 10 degrees below 80 degrees F. Some hydrometers are equipped with a thermometer below the float. Example, if the float reading is 1.150 and the battery solution temperature is 100 degrees F., then add .004 for each 10 degrees F. above 80. This equals 20 x .004 = .008 1.150 + .008 = 1.158.

(4) Check for a difference in readings between the cells. If the reading is more than 0.050 (50 sp. points) between cells, this may indicate that the battery needs replacing.

(5) Another type of battery tester is the amperes-volt (capacity) test. This test is performed on batteries with a specific gravity rating above 1.220. A slow charge should be used to increase the specific gravity above 1.220. An ammeter-voltmeter is connected to the battery by attaching positive leads to the positive post and the negative leads to the negative post. The instrument switch should be off to prevent sparking when connecting leads.

h. Starting Motor Tests - There are many tests that can be performed on the starting motor. Some of these tests are: load, no-load, stall torque, open circuit, ground, brush, solenoid, and switch.

(1) The starter load test can be made by using a voltmeter, ammeter, and carbon pile rheostat. The test shows the amount of current (in amperes) used and starter condition. The test is made by grounding the coil distributor lead to prevent engine from starting. Then set the carbon pile instrument to full resistance and take voltmeter reading while cranking the engine. Reduce the resistance until the reading on the voltmeter is the same as when cranking the engine, then take the ammeter reading. This reading indicates the amount of current drawn during cranking. Use the manufacturer's recommendations to make a comparison and adjustments.

Transparency No. 4

(2) To make a no-load test, remove the starter and disconnect the starter ground cable. Then reconnect the battery negative lead to the starter

ground terminal. Eliminate the possibility of current flow by setting the carbon pile resistor which is connected to both battery posts. Connect a high amperes ammeter to the battery positive post and solenoid battery post, if the solenoid is mounted on the starter. Connect the voltmeter to this same post and to the starter terminal. Use a tachometer on the end of the armature to check the armature speed. The reading is checked similarly to the load reading; that is, the ammeter gives the no-load current draw.

(3) The stall torque test is made in the same way as the no-load test except a torque attachment and scale is attached to the starter armature shaft. The test is made quickly in order to prevent over heating of the starter. Torque is measured in foot pounds, and the ammeter indicates current draw. This test may reveal a dirty commutator, loose connections, open windings, shorted winding, dragging armature, or frozen bearings. Switches, windings, and solenoids can also be tested by use of proper gauges and battery.

Transparency No. 4

1. Major Generator and Alternator Tests - Testing equipment for the generator output test includes an ammeter, variable resistor, voltmeter, tachometer, and jumper wire. The three regulator tests (oxidized points test, voltage test, and current test) will not be discussed in this topic. Test lamp testing is explained in detail in Unit C, Topic 5, also testing the regulator is explained in this Topic (C-5). The procedure for making the test is as follows:

(1) After checking all wire leads, connections, and brushes, disconnect leads to the generator field terminals and armature.

(2) To test the output, connect the ammeter to the generator armature terminal and variable resistor. The resistor is connected to the two battery posts. Connect the voltmeter to the ground terminal and armature terminal. Also, connect a lead from the battery to the generator ground, then connect the jumper wire to the ground and field terminals on the generator. Set the resistor for least resistance. Run the engine as specified and adjust resistor to obtain proper voltage. It may operate at 14 volts for a 12 volt circuit. Follow generator specifications for reading output on the ammeter. This could be 20 amperes for a 12 volt circuit and 10 for 24 volt circuit.

(3) The generator resistance test is made by connecting an ammeter to the regulator terminal and to the regulator wire removed from the terminal.

Place a jumper on the field terminal and ground on the generator. Turn all accessory switches off and operate the engine at 10 amperes, but no more than this rate. Check the voltage as follows:

(a) Battery negative terminal to the armature terminal.
(b) Regulator base connection to some place on the generator frame.
(c) Battery positive terminal to the generator frame.
(d) After removing the jumper connection on the generator, continue the charging rate (10 amperes) with the lights on. It may be necessary to connect a resistor to the + and - posts on the battery to maintain the 10 amperes. Check voltage from the regulator field terminal to the generator field terminal.

Transparency No. 5

(4) The four major tests that can be performed on the alternator are: the stator assembly, diodes, brush, and rotor.

(a) When using an armature tester to test the stator, disconnect the diodes from the stator. The stator leads should be disconnected from each diode assembly. Connect an ohmmeter to the alternator frame and a stator lead to check for grounded winding. The reading will be infinite if the winding is not grounded. Check for an open circuit on a Y-stator by using an ohmmeter attached to the stator leads. A sensitive ohmmeter may be used to check the delta-connected stator for short-circuited winding or open circuit. The ohmmeter reading is 0.2 ohm for a Y-stator and 0.1 ohm for a delta stator.
(b) With a 1 1/2-volt ohmmeter connect one lead to the diode case and the other lead to the diode lead. Check the reading and reverse the lead connections, taking the reading again. The diodes are considered in good condition if the readings are the same.
(c) To check the brush continuity connect one ohmmeter lead to the brush assembly field terminal and the other lead to the brush. Brush insulation is checked by connecting the ohmmeter lead to the field terminal and the assembly bracket. If the resistance is not infinite the assembly must be replaced due to a short. In the continuity test the reading should be zero.
(d) To test the rotor assembly for shorts and open circuits, use an ohmmeter. Attach one ohm lead to the first slip ring and the other lead to the second slip ring. Open windings will give a high reading. Use an ohmmeter with one lead on a slip ring and the other on a rotor shaft to test for grounds. A low reading shows the windings are grounded. Use of test lamp is explained in Unit C, Topic 5.

j. Air Intake System Tests - These tests are made to determine if there is a restriction that may cause oil to be drawn in around the valves and by the piston rings. The steps in testing spark ignition and diesel engines are as follows:

(1) To perform the spark ignition manifold depression test, use a vacuum gauge that is calibrated in inches of mercury. After connecting the gauge to the intake manifold, operate the engine at idle speed and take a reading when the engine is running warm. Compare the reading with the technical manual recommendations. A steady low reading indicates a loss of power, needle fluctuation indicates partial loss of power, and a slow drop of the needle shows back pressure and a restriction.

(2) Some diesel engines have restriction indicators; therefore, the indicator is removed, a tee fitting installed, indicator reinstalled, and vacuum gauge connected to tee fitting. If there is no restriction indicator on the engine, connect the gauge in the same manner used on the spark ignition engine. The engine is operated at fast idle for gauge reading. A high reading indicates a restriction in the intake manifold system. The engine technical manual will give the specification to use. Restriction indicators can be also used to determine whether or not there is a restriction in the manifold system.

Transparency No. 6

k. Testing The Hydraulic System - Hydraulic testers can be found from the single unit pressure gauge to a four unit analyzer. The analyzer contains a flow meter, temperature gauge, low pressure gauge, and high pressure gauge. It also is equipped with a load valve control knob. Some testers are equipped with a volume range selector (rate of flow regulator). The type of tester is determined by the way the testing unit is connected to the hydraulic system. The three most common types are: bypass, in-line, and tee. These testers measure oil flow, temperature, and pressure, and they isolate leaks.

(1) Due to the pump being the hydraulic system generating force, testing starts at this point. The "bypass" method of installing and operating the tester is as follows:

(a) Open line between control valve and pump after pressure has been released in the system.

(b) Connect pressure line from the pump to the tester inlet opening and connect the tester outlet line to the reservoir. This connection system is known as the bypass test.

(c) Slowly close the tester load valve until the desired temperature is reached. This valve should be opened at the beginning of any test. The closing of the valve actually increases the pressure.

(2) When using a "bypass" tester at pressure and the load valve open observe the maximum pump flow. Increase the pressure by closing the load valve. Beginning with 250 pounds per square inch record the maximum pressure at each 250 psi. Example: 250, 500, 750, etc. Reduce pressure to "0" by opening tester load valve. Turn off the engine. Maximum pressure flow should be 75 percent of the "0" pressure flow.

(3) When using an "in-line" tester connect it in the line as part of the system. Disconnect the outlet line from the hydraulic system and connect it to the inlet side of the tester; then connect the outlet side of the tester at the disconnected pump connection.

(4) The "tee" test is also a commonly used test when checking the complete hydraulic system. A tee installed between the pump and system control valve makes a flow line available to the tester inlet opening. The tester outlet opening enters the system reservoir. The operation of this testing system is as follows: Record the rate of flow as the hydraulic control lever is moved to each position. If the flow rate drop is more than 15 percent in all lever positions, the problem may be in the pump. If the flow rate loss is in one or two positions, the problem may be in the cylinder or valves.

Transparency No. 6

1. Injection Nozzle Test - The tester consists of a high pressure gauge, high pressure hand pump, and tester valves. The valves are pump isolation, gauge protection, and on-off. The nozzles are usually tested for the following problems: valve leakage, opening pressure, chatter, and spray pattern. Steps in testing nozzles include:

(1) Connect the injection nozzle to the tester by following tester manual instructions and enclose nozzle in a transparent container. This procedure will protect the hands from the spray pattern.

(2) With the gauge closed flush the nozzle by making fast strokes with the handle. Only the isolator valve should be open. This rapid pump operation should clear the pump fuel connector line and in-

jector of air.

(a) To test for opening pressure close the on-off valve and open the pump isolator and gauge protection valves. Operate the hand pump lever until the nozzle makes a "pop" noise and take a gauge or opening pressure reading at this point. Compare the reading with the manufacturer's manual. Follow manufacturer's specifications when adjusting nozzle.

(b) When testing a nozzle for leakage, close the on-off valve and the gauge protector valve. Open the pump isolator valve. Pump the tester rapidly and dry the nozzle tip. Open the pump isolator valve and gauge protection valve. Close the on-off valve and increase the pressure as specified in the service manual. Some wetting may be permissible on the tip after a few seconds. Increase and maintain nozzle pressure with the nozzle inverted. Refer again to manual specifications for return leakage.

(c) When testing for chattering, close the on-off and gauge protector valves. Open the pump isolator valve and pump the tester with rapid strokes. Chatter should be regular and distinct. Use the service manual for recommendations.

(d) Test the spray pattern by keeping the on-off and gauge protector valves closed and the pump isolator valve open. Pump the tester rapidly and observe the spray pattern. The atomized spray should be distributed evenly. If large droplets or a stream is discovered in this test it may be necessary to disassemble the nozzle for service.

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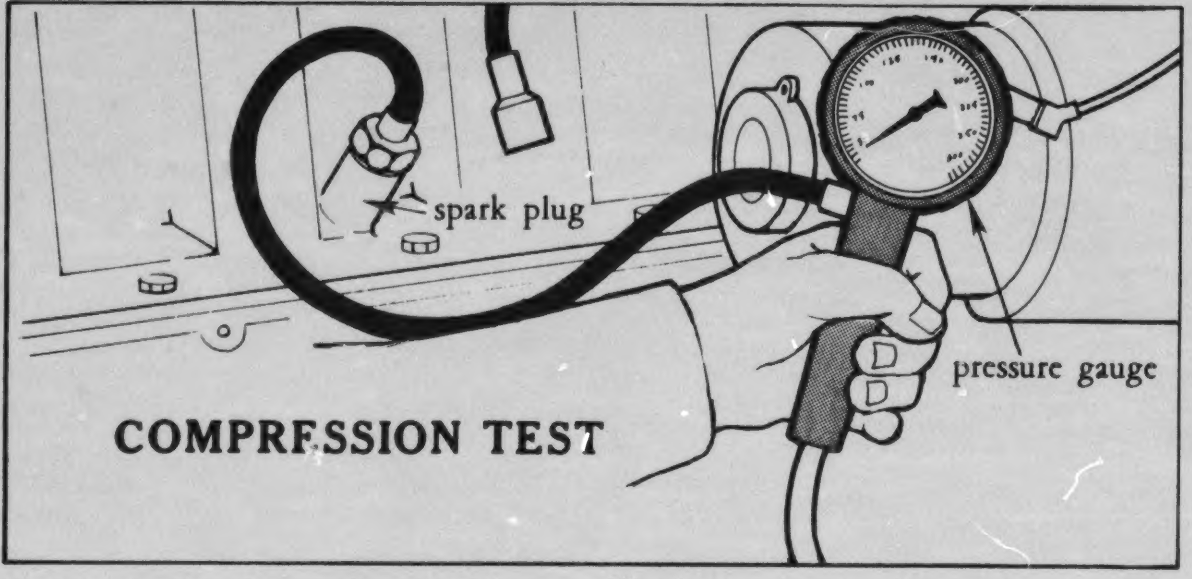
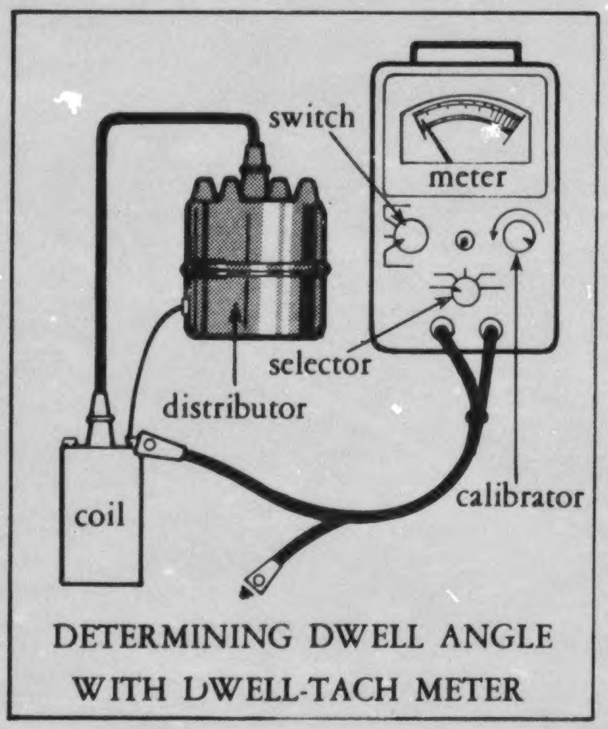
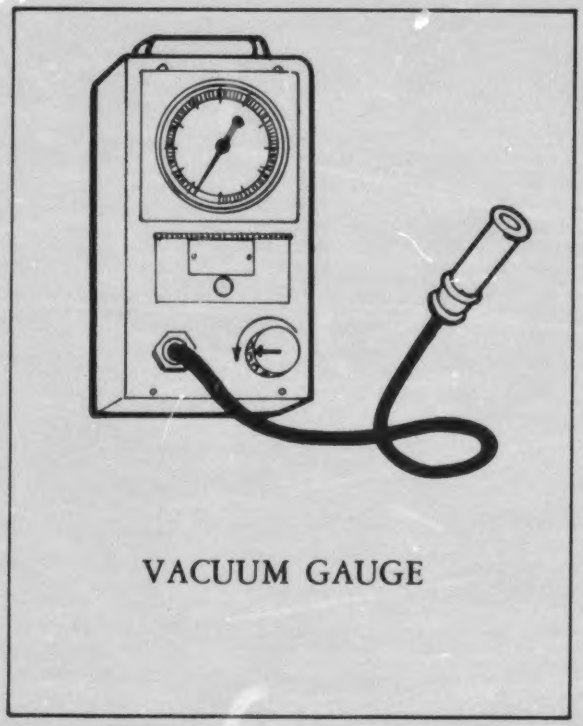
TESTS & TESTING EQUIPMENT


spark plug
pressure gauge

COMPRESSION TEST

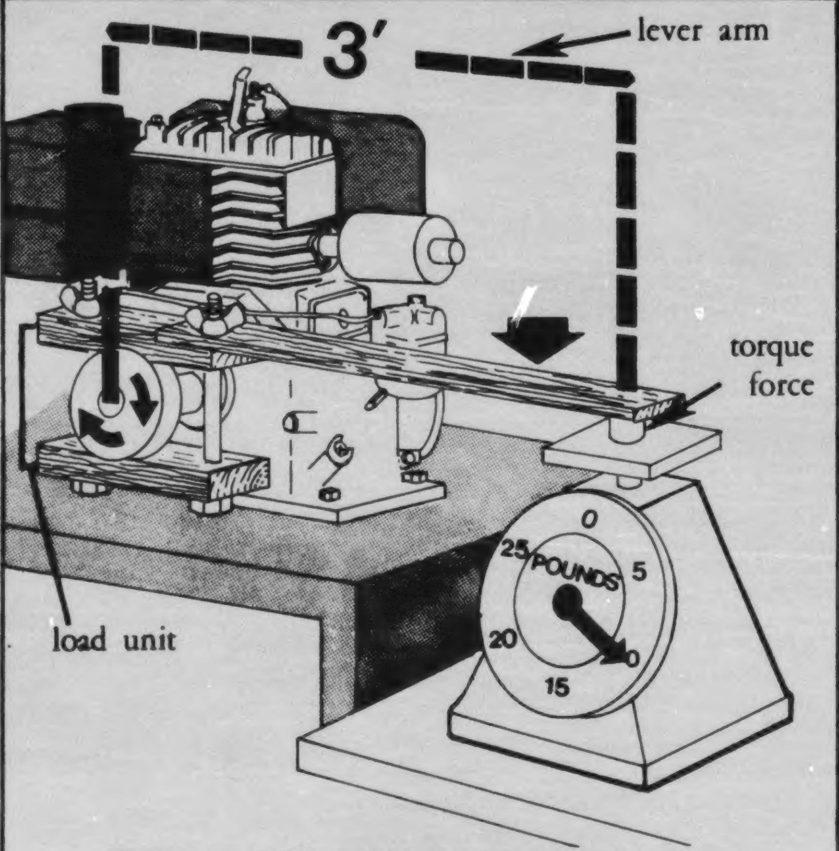

switch
meter
selector
distributor
calibrator
coil

DETERMINING DWELL ANGLE WITH DWELL-TACH METER

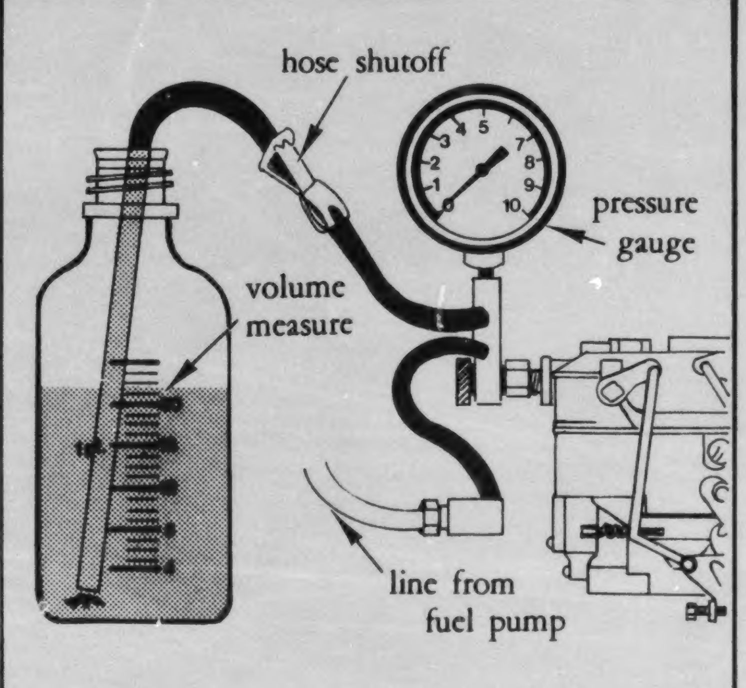


VACUUM GAUGE

TESTS & TESTING EQUIPMENT

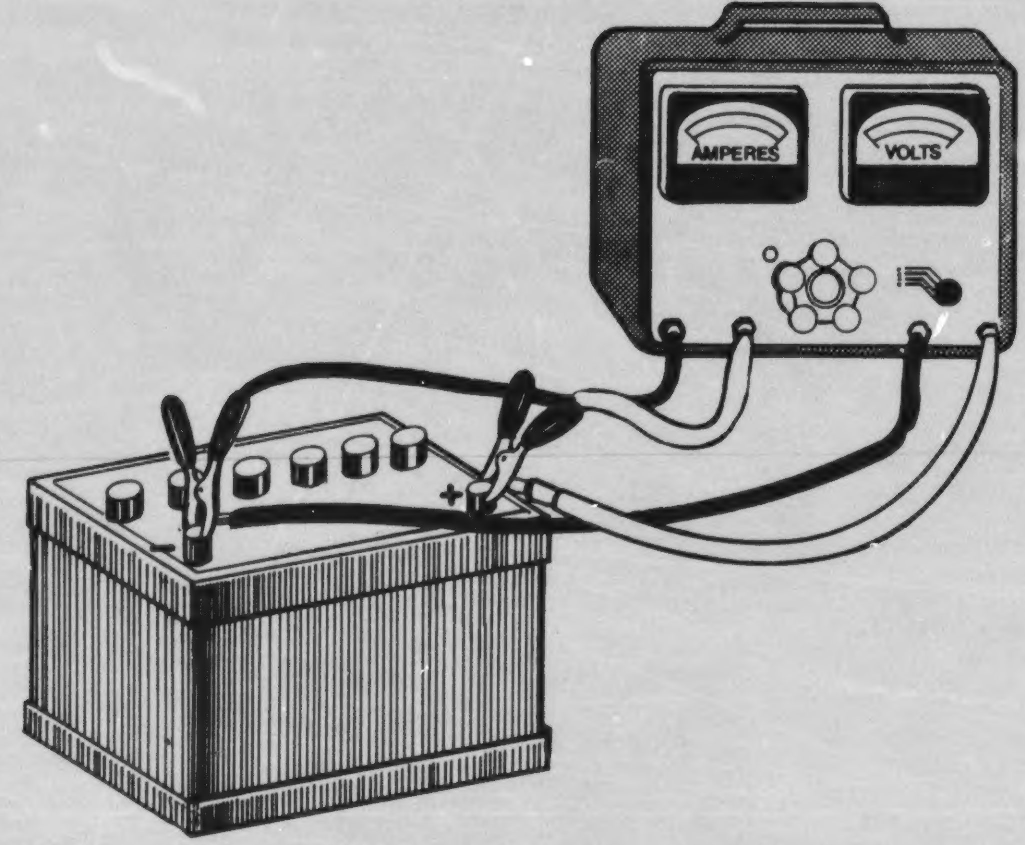

3′
lever arm
torque force
load unit
0
5
10
15
20
25
POUNDS

TYPE OF DYNAMOMETER


hose shutoff
pressure gauge
volume measure
line from fuel pump
0
1
2
3
4
5
7
8
9
10

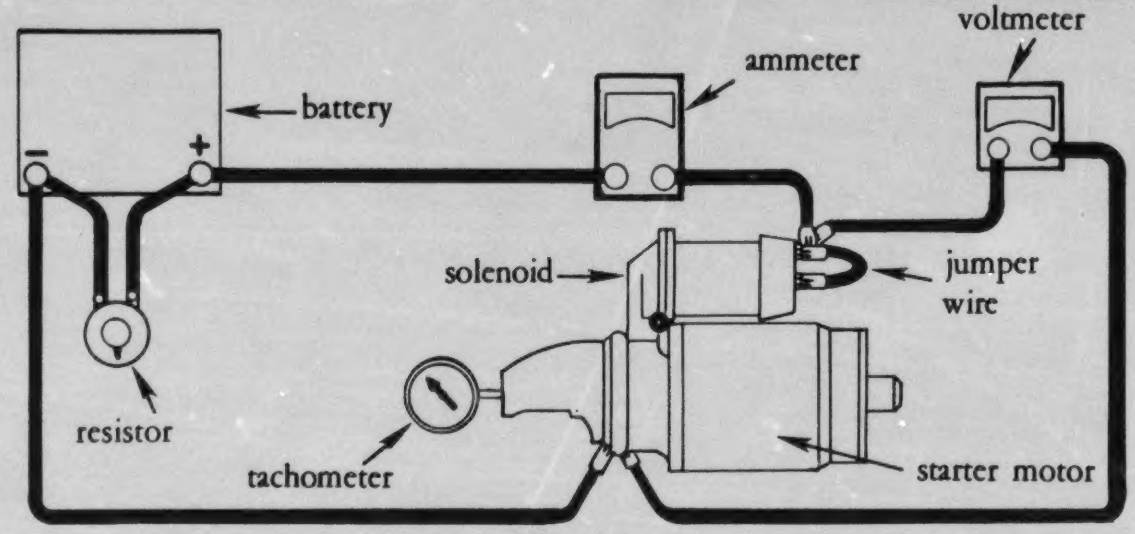
FUEL PUMP PRESSURE & VOLUME TESTER

TESTS & TESTING EQUIPMENT

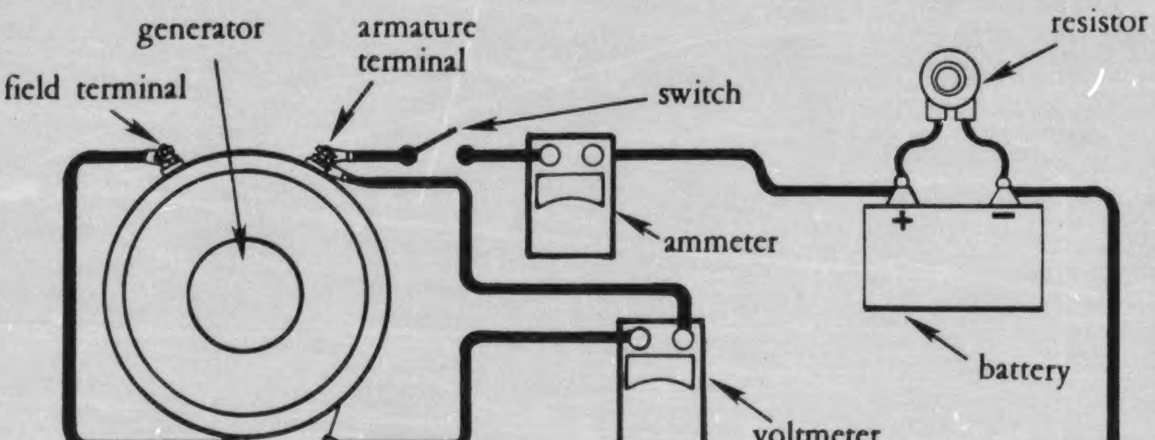

AMPERES
VOLTS
+
-

BATTERY AMPERES - VOLT TEST

TESTS & TESTING EQUIPMENT

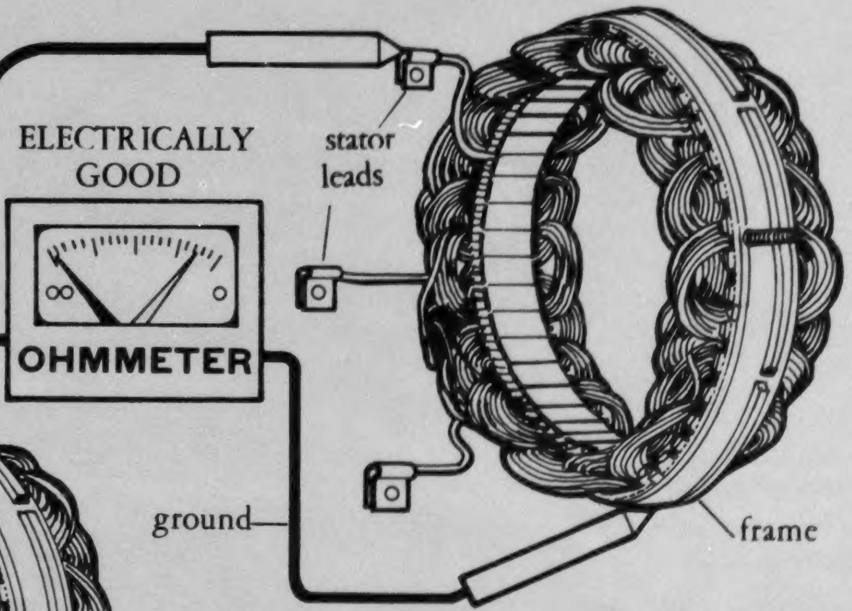

voltmeter
ammeter
battery
−
+
solenoid
jumper wire
resistor
tachometer
starter motor

STARTER NO-LOAD TEST

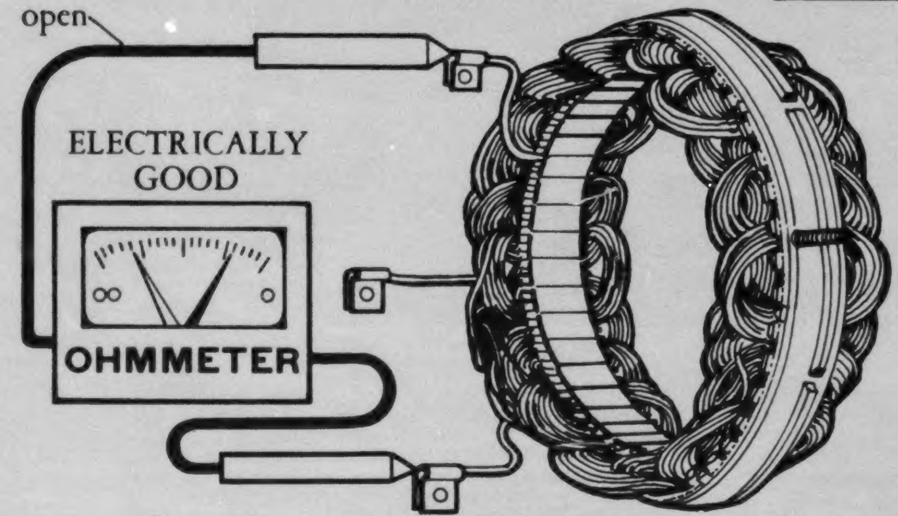

generator
armature terminal
resistor
field terminal
switch
ammeter
+
−
battery
voltmeter
ground area

GENERATOR OUTPUT TEST

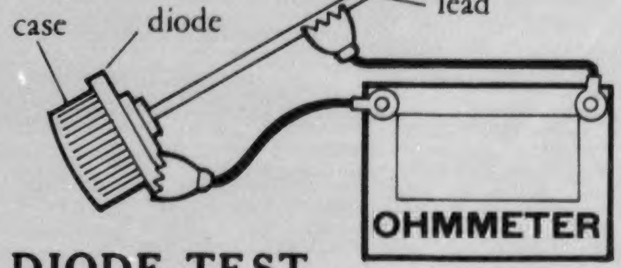
TESTS & TESTING EQUIPMENT


ELECTRICALLY GOOD
∞
0
OHMMETER
stator leads
ground
frame

ALTERNATOR GROUND TEST

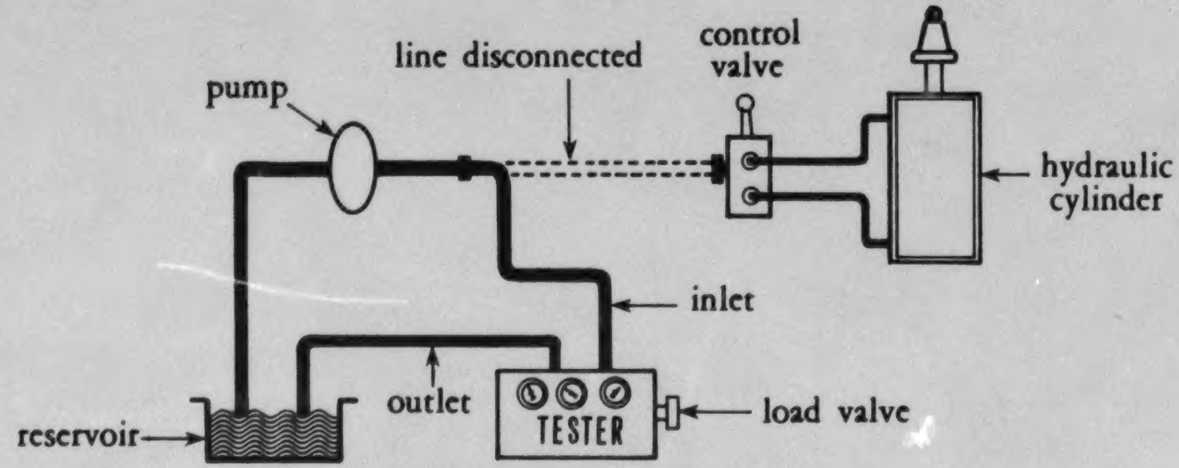

open
ELECTRICALLY GOOD
∞
0
OHMMETER

ALTERNATOR OPEN TEST

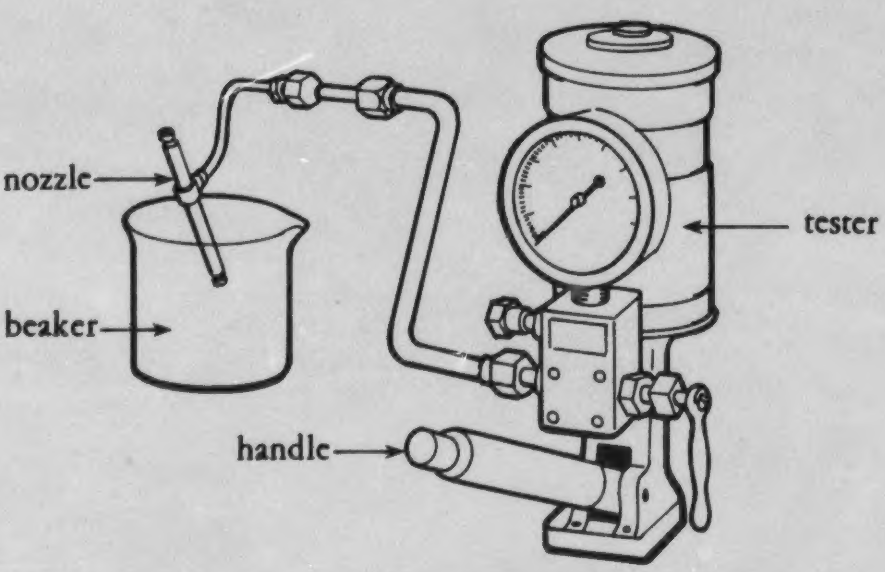

case
diode
lead
OHMMETER

DIODE TEST

TESTS & TESTING EQUIPMENT


line disconnected
control valve
pump
hydraulic cylinder
inlet
outlet
TESTER
load valve
reservoir

HYDRAULIC PUMP TEST


nozzle
tester
beaker
handle

DIESEL NOZZLE PRESSURE TEST

GENERAL AGRICULTURAL MECHANICS

Unit B: Diagnosing Engine and Engine System Conditions

Topic 4: Selecting and Using Precision Measuring Tools

Suggested Procedures and Activities: During the class discussion, have tools available to present along with the transparencies. Most visuals are based upon general information and some tools vary according to trade name.

1. General Information

Precision tools are used mainly in power and machinery mechanics shops to check sizes of inside and outside measurements, check clearances, and check alignments. There are many types of precision measuring tools used in the farm machinery shop. Some of the most common tools are: micrometers, calipers, gauges, scales, dividers, and straight edges.

Transparencies Nos. 1 and 2

2. Micrometers and Their Use

a. Types of micrometers include:

(1) Outside - The outside micrometer is used to check the diameter of pistons, crankshafts, pins, and camshafts and the outside dimension of other parts in thousandths of an inch. The thimble is turned until an anvil face and spindle face touch the object.

(2) Inside - This type of micrometer is used to determine the measurements in cylinder bores, brake drums, and certain bushings. There are two types -- for small and large measurements. The thimble is turned to spread the jaws apart until they touch both sides of the opening.

(3) Depth - The depth of openings such as slots and holes are measured by the depth micrometer. The base is placed over the opening, and the pin is run down by turning the thimble until the pin reaches the bottom of the hole or opening. There are several different widths of depth gauges used on depth micrometers.

b. The principal parts of an outside micrometer include:

Rachet stop	Frame
Thimble	Anvil
Barrel	Measuring faces
Spindle	

The thimble and barrel are marked with scales for making measurements.

c. There are two major measurements used on micrometers. One type of micrometer is graduated in hundredths of a millimeter. This is a metricmeasure micrometer. The other type is graduated in thousandths of an inch and is called an English measure micrometer. Steps in using a micrometer are:

(1) Select the proper size of micrometer for making the measurement and adjust the opening a little larger than the thickness of the object to be measured.

(2) Place the thimble between the thumb and forefinger and turn the thimble until the spindle and anvil points contact the object being measured.

(3) Turn the rachet two clicks, that is, if the micrometer is equipped with a ratchet. If a non-ratchet type is used, pressure is determined by "feel". Do not tighten the thimble so that the micrometer cannot be easily removed from the object.

(4) If possible, take the reading while the micrometer is attached to the object. The reading may be takeh after the micrometer is removed if care is taken not to move the spindle.

(5) Readings may be made with calipers in places that are hard to measure with the micrometer, and the reading may be transferred to an inside micrometer.

Take the reading by using the following procedure:

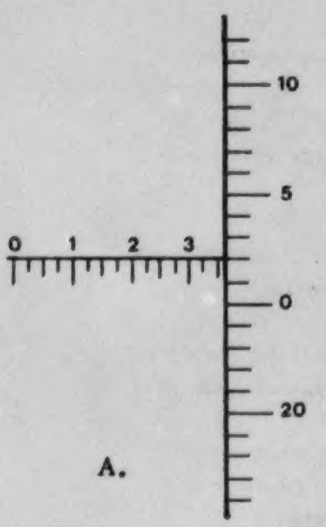
Read the highest figure on the barrel.

Read the number of lines that are visible on the barrel above the highest figure.

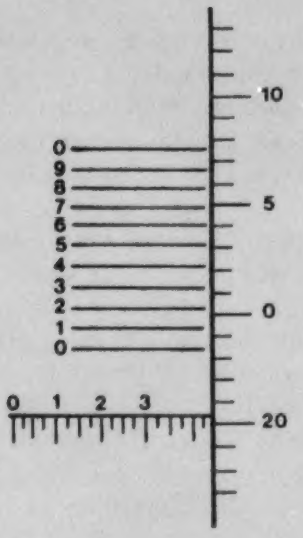
Read the thimble line that is in line with the datum line.

If the micrometer has a vernier scale, read only the vernier scale line that coincides exactly with the thimble line.

Micrometer readings without and with a vernier scale:



A.



B.

A.

Sleeve or barrel	3 =	.300
Sleeve or barrel	2 =	.050
Thimble	2 =	.002
Total		.352

B.

Sleeve or barrel	4 =	.400
Sleeve	1 =	.025
Thimble	20 =	.020
Barrel-Vernier	=	.0006 (6/10,000)
Total		.4456

Transparencies Nos. 3 and 4

3. The use of calipers, gauges, scales, dividers, and other similar measuring tools are as follows:

   a. Calipers - Calipers are used to measure outside and inside surfaces when accuracy is not considered critical. Measurements can be taken from the caliper by using a steel ruler or micrometer.

   b. Dial Gauges - These gauges are used for measuring movements in thousandths of an inch. Various mounting arms, brackets, and adapters are used to mount the dial gauges so that they can be used for checking backlash between gears, valve lift, play in shafts, and cylinder taper.

   c. Dial Cylinder Gauges - Cylinder gauges are used to check cylinder bore size, taper, and out of roundness.

d. Telescope Gauges - These gauges are used to measure grooves, slots, or inside cylinder walls. They are also used to measure inside the bore of bearing walls. An outside micrometer is used to measure across the plungers of the telescope gauge after a bore measurement is taken. These tools may be purchased in sets ranging from 1/2 to 2-1/2 inches.

e. Feeler Gauges - Feeler gauges are used to check clearances between two parts such as valve gaps and piston ring gaps. There are several blades in one set. The blades are marked in thousandths of an inch. The blades on stepped feeler gauges are two different thicknesses, the tip being thinner than the rest of the blade.

f. Wire Gauges - Wire gauges are used to check the points in a distributor and to set spark plug point gaps. They are made of steel wire.

g. Screw Pitch Gauges - These gauges are used to determine the number of threads per inch. They are also used to determine the depth of threads.

h. Spring Scales - Spring scales are used to determine the contact point pressure by ounces or pounds of pull on feeler strips when pistons are being fitted. They also may be used for certain torque tests.

i. Dividers - Dividers are used for marking circles and taking surface measurements. These measurements can be taken from the divider by a rule or micrometer. Usually measurement transfer is made directly from the divider points.

j. Steel Straight Edges - This type of straight edge is used to check engine blocks for warpage. It should be long enough to span the entire block. The straight edge can also be used for alignment on some jobs.

k. Combination Square - A combination square equipped with the square head, protractor head, and center head is considered as a precision measuring tool for the machine shop.

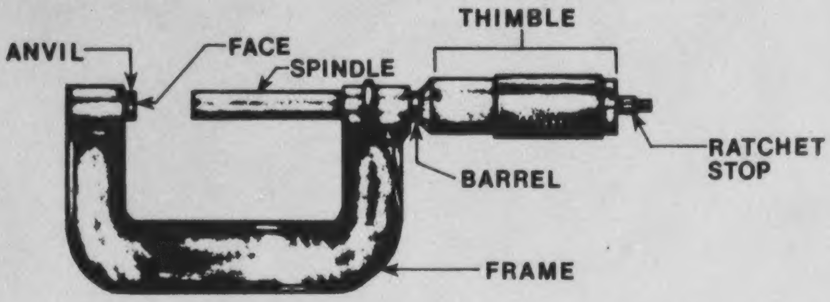
l. Other Measuring Tools - A sliding head hook rule, six inch steel rule marked in 32nds and 64ths of an inch, and a ten foot metal pocket tape are very important measuring devices in a mechanics shop.

References:

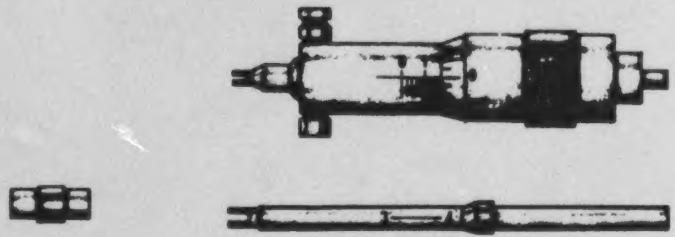
1. Stockel, Martin W., Auto Service and Repair, The Goodheart-Willcox Company, Inc., South Holland, Illinois, 1969

2. "Fundamentals of Service Tools", Deere and Company, Moline, Illinois, 1973

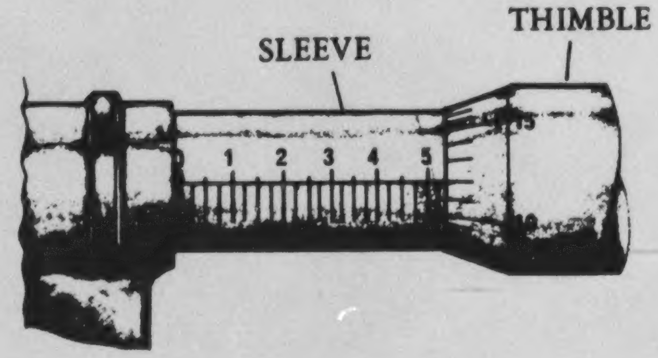
PRECISION MEASURING TOOLS


THIMBLE
ANVIL
FACE
SPINDLE
RATCHET STOP
BARREL
FRAME

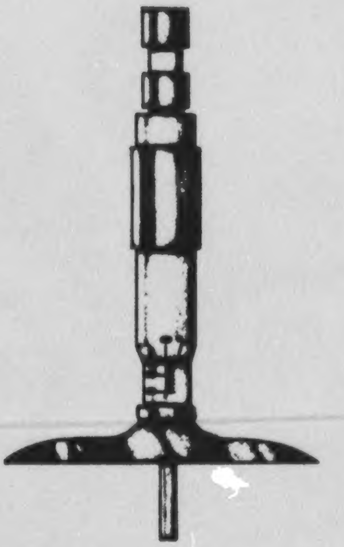
OUTSIDE MICROMETER



INSIDE MICROMETER

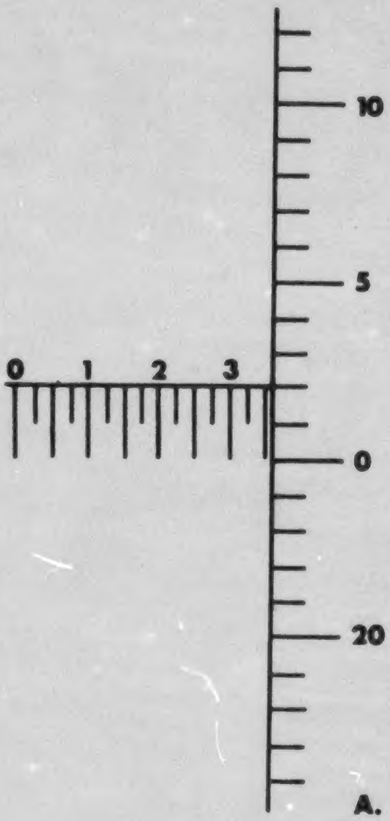

THIMBLE
SLEEVE
1
2
3
4
5
15
10

MICROMETER READING .537

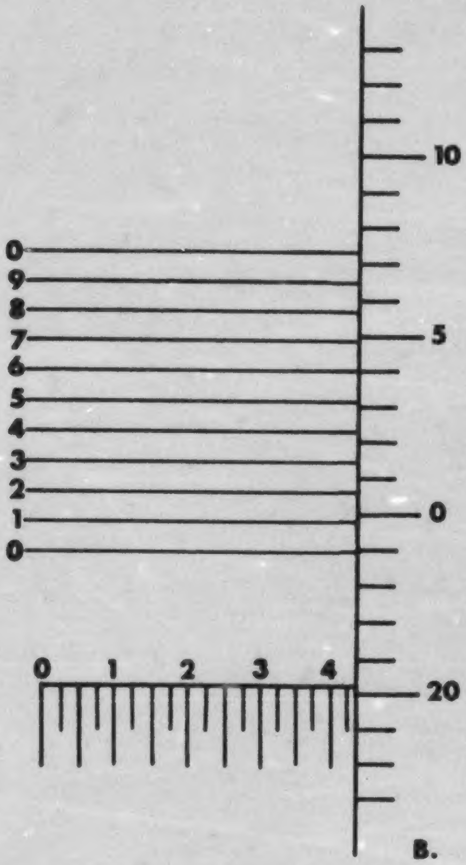


DEPTH MICROMETER

READING A MICROMETER


10
5
0 1 2 3
0
20

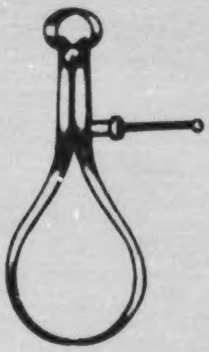
A.


10
0
9
8
7
5
6
5
4
3
2
1
0
0
0 1 2 3 4
20

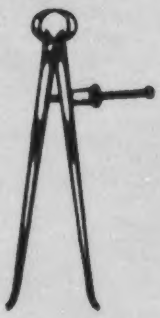
B.

A.	**Sleeve**	**3 = .300**
	Sleeve	**2 = .050**
	Thimble	**2 = .002**
	TOTAL	**.352**
B.	**Sleeve**	**4 = .400**
	Sleeve	**1 = .025**
	Thimble	**20 = .020**
	Barrel – Vernier	**= .0006 (6/10,000")**
	TOTAL	**.4456**

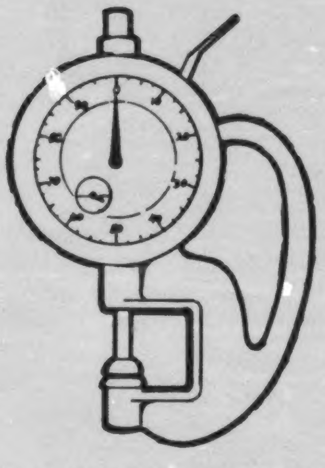
PRECISION MEASURING TOOLS



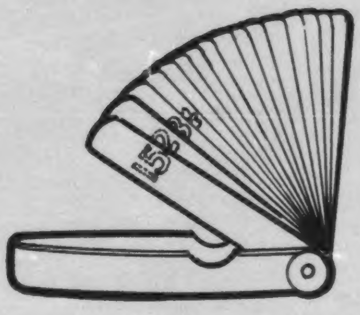
OUTSIDE CALIPER



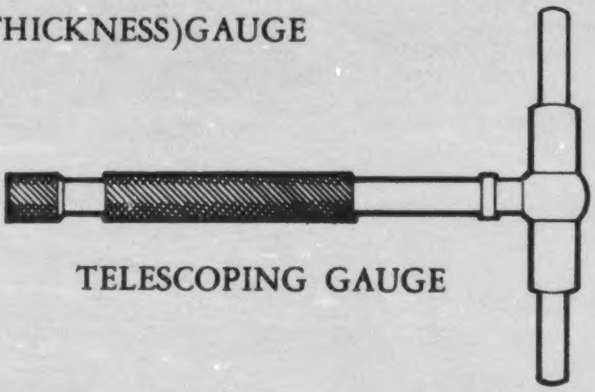
INSIDE CALIPER



DIAL(THICKNESS)GAUGE

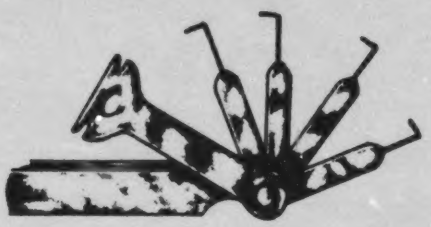


FEELER GAUGE

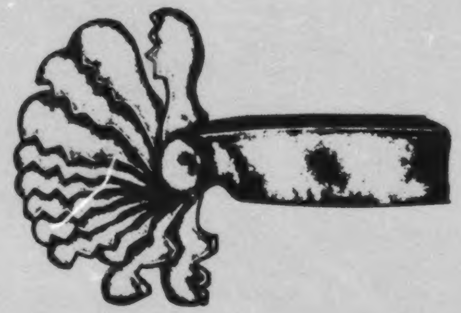


TELESCOPING GAUGE

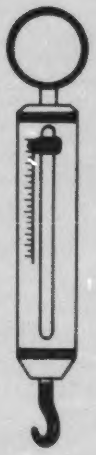
PRECISION MEASURING TOOLS



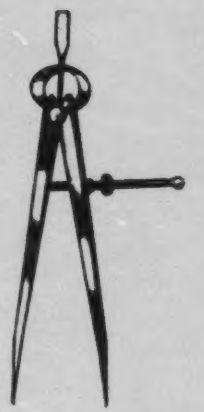
WIRE GAUGE



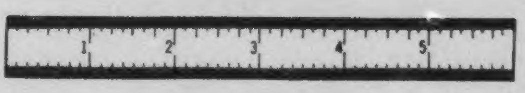
SCREW PATCH GAUGE



SPRING SCALES



DIVIDERS



STEEL RULE

GENERAL AGRICULTURAL MECHANICS

Unit B: Diagnosing Engine and Engine System Conditions

Topic 5: Recognizing Common Troubles

Suggested Procedures and Activities: Each student may list the cause and correction of engine problems in the notebook during class discussion. A large chart showing the cause of the problem on one side and remedy opposite the cause may also be beneficial.

1. Locating Common Troubles

In order to maintain an engine and its different systems, it is necessary that a constant check and trouble shooting program be used when the engine is operating and idle. One of the better systems developed to locate and correct common problems is the use of a trouble shooting or problem diagnosis chart. The chart should show the problem, cause of the problem, and the correction or remedy. It is true that some problems cannot be diagnosed by the operator; therefore, the engine should be taken to a service and repair shop. Some of the reasons why an operator cannot diagnose problems are:

a. There is a lack of proper testing equipment available.

b. Lack of mechanical knowledge to diagnose and correct the problem.

c. Shop, hand tools, and equipment are not available to make repairs.

d. Testing and repair can usually be performed more rapidly and thoroughly by a skilled mechanic.

e. Parts of the engine system (electrical and fuel) can only be repaired in a service shop.

2. Problem or Trouble Shooting Chart

Possible Cause	Possible Correction or Remedy
Problem: Consuming Oil	
Oil weight too light. Worn piston	Use heavier weight of oil. Re-

rings and pistons. Oil leaks.	place piston rings. Make repairs to eliminate leaks.
Air intake system contains restriction.	After checking system remove restriction.
Worn valve stem, oil seals, and worn valve guides.	Replace seals and guides.
High oil pressure.	Adjust oil pressure.

Problem: Lack of Power

Air cleaner clogged or dirty.	Clean, remove obstruction or replace air cleaner.
Improper adjustment or dirty carburetor.	Clean and adjust carburetor.
In spark-ignition burned distributor points.	Replace distributor points and condenser.
Fouled spark plugs in spark-ignition engine.	Replace spark plugs or clean and set gap on old plugs.
Out of time.	Reset distributor on spark-ignition engine.
Low compression.	Repair engine to correct compression.
Leaking valves in engine head or incorrect valve clearance.	Recondition valves and set at proper clearance.
Fuel lines, carburetor or filter restricted.	Remove restriction by cleaning fuel system parts.
Improper type of fuel.	Use only fuel recommended for engine.
Fuel-lock strainer frosted on L. P. gas engine.	Clean the fuel-lock strainer.
Improper operation of governor.	Adjust or repair governor.

Problem: Engine Overheats

Lack of the proper amount of coolant.	Add coolant to recommended level.
Lack of proper radiator cap pressure.	Test radiator cap and replace if defective.
Stuck or defective thermostat.	Test thermostat for proper functioning.
Loose or worn fan belt.	Adjust fan belt tension or replace if worn.

Incorrect timing on spark-ignition engine.	Properly set the distributor.
Engine overloaded.	Operate engine at the proper gear ratio and reduce carrying load.
Lack of the proper amount of oil in crankcase.	Add enough oil to bring it to the proper level.

Problem: Engine Fails to Start or is Hard to Start

Lack of the proper fuel or no fuel.	Remove remaining fuel and fill with proper fuel or add fuel.
Failure to use clean fuel.	Change filters and remove dirt and water from the system.
Failure to generate enough cranking speed.	If the battery is the problem, replace it or repair starting motor.
Engine floods.	Stop choking engine and wait a few minutes before attempting to start it again.
Defective spark plugs.	Replace plugs with proper gap setting.
Coil and/or condenser defective.	Replace both coil and condenser if both found defective.
Loose or improperly installed distributor wires.	Replace wires in proper order and seat firmly on plugs.
Defective distributor cap and points.	Replace cap and points.
Fuel system contains air (diesel).	Remove air by bleeding lines.
Defective injection nozzle operation.	Test and repair or have nozzles repaired.

Problem: Battery Condition

Electrolyte level low.	Add distilled water to recommended level to each battery cell.
Fails to charge properly.	Test specific gravity. Clean battery and battery terminals. Tighten drive belt if necessary and test generator or alternator input. Test for grounds and shorts. Reduce battery excessive loads.

Damaged battery case and/or defective cell.	Replace battery.
Overcharging battery.	Test voltage regulator as full load is applied to battery.
Using excessive amount of water.	Reset the voltage regulator or current regulator.

Problem: Engine Starts but Fails to Run

Dirty filters, dirt in fuel system, air restricted causing fuel problem.	Replace or clean dirty filters, bleed diesel system, correct restriction.
Carburetor out of adjustment.	Adjust idle mixture and idle speed screws.
Defective engine switch or ignition resistor.	Replace switch or resistor.
Defective condenser or coil.	Replace condenser or coil.

Problem: Engine Fails to Run Smooth (Misses)

Damaged cables to spark plugs or corroded spark plugs.	Test and replace faulty cables. Clean spark plugs.
Dirty fuel (water or dirt), mixed fuel (diesel mixed with gasoline).	Drain entire system and refill with clean fuel.
Air in a diesel fuel system.	Remove the air by bleeding the system.
Damaged or cracked distributor cap (spark-ignition engine).	Replace distributor cap.
Improperly adjusted carburetor (spark-ignition engine).	Make proper carburetor adjustments.
Injection nozzles failing to function properly (diesel).	Check spray pattern after cleaning nozzles.
Nozzles improperly positioned in the cylinder head (diesel).	Remove nozzles, reposition and use torque wrench to tighten retaining screws.
Improperly calibrated injection pump (diesel).	Properly calibrate pump.

Problem: Other Engine Conditions

Backfiring noticed in spark-ignition engine due to cables being installed improperly or the air-fuel mixture is incorrect.	Check spark plug cable positions and place in proper firing order. Adjust air-fuel mixture.

Fuel pre-ignites in gasoline engine due to early timing, advance mechanism stuck, carbon in cylinder or high plug heat range.	Use timing light and adjust distributor, free advance mechanism and test, clean carbon from cylinders, and use the proper type of spark plugs.
Knocks or pinging noise in engine due to worn bushings or bearings, improper timing, endplay of crankshaft, bearing caps loose, or cylinder containing foreign material.	Properly time engine, replace bearings or bushings, adjust endplay, properly tighten bearing caps, and remove foreign matter from cylinders.

References:

1. Stockel, Martin W., Auto Service and Repair, The Goodheart-Willcox Company, Inc., South Holland, Illinois, 1969

2. Toboldt, William K., Diesel - Fundamentals, Service, Repair, The Goodheart-Willcox Company, Inc., South Holland, Illinois, 1973

3. "Fundamentals of Machine Operation - Preventive Maintenance", Deere and Company, Moline, Illinois, 1973

GENERAL AGRICULTURAL MECHANICS

Unit C: Servicing the Electrical System

Topic 1: Servicing the Battery

Suggested Procedures and Activities: If possible use a cut-away battery during the class discussion. This type of teaching aid can be made by cleaning an old battery with soap and water and removing one side in order that the students may see the plate groups, separators, and other parts.

1. The Purpose and Function of A Battery

The battery is considered the starting point of the ignition system. It supplies electrical current for starting the engine, helps regulate the voltage in the system, supplies current to other parts of the ignition system, and receives current input from the generator or alternator. It produces a current through a chemical reaction of the materials of the positive and negative plates. Positive plates contain lead peroxide (PbO_2), and negative plates contain spongy lead material (Pb). The liquid material (electrolyte) is made up of sulfuric acid 36% and water 64% ($H_2O + H_2SO_4$ = Electrolyte). The discharge of a battery begins when it is connected to a complete circuit. Lead sulphate ($PbSO_4$) is formed at both negative and positive plates as the battery is discharged. As the sulphate increases the voltage decreases.

The main battery terminals are the negative (-) and positive (+) posts. The positive post is usually the larger of the two to help prevent connecting the battery incorrectly. Vent caps are in each cell cover. The caps all have two purposes.

> They close up the opening in the top of the cell cover through which the electrolyte is checked and fresh water is added.
>
> They provide a vent for the escaping gases formed by the charging of the battery.

The battery ignition system usually consists of the following components: battery, ammeter, ignition switch, resistor, ignition coil, spark plugs, and high and low tension wiring. The generator or alternator may also be considered part of the battery system.

Batteries are of two sizes, 6-volt and 12-volt. There are three cells in a 6-volt battery and 6 cells in a 12-volt battery. A 12-volt battery has more power for lights and starting the tractor.

2. Types of Batteries

The types of batteries are as follows:

a. The Dry-Charged Battery - This battery contains fully charged elements. It does not have any electrolyte until it is activated for service. It leaves the factory in a dry state. The elements are specially charged at the factory by a direct current being passed through the plates while immersed in an electrolyte of sulfuric acid. The plates are taken out, washed in water, and dried, and the battery is assembled. To activate a dry charged battery:

(1) Remove the seals at the battery cell opening and remove vent caps.

(2) Carefully fill up each of the cells with approved electrolyte to the proper level. Fill to about 3/8 inch above the top of the separators. Check vent caps to see if they will vent and put them in place on the battery.

(3) Check the battery with a battery type hydrometer before installing on machine (tractor or engine). A thermometer placed in the center cell will give the battery temperature. The specific gravity should be above 1.240 and the temperature above 80 degrees F. before the battery is installed.

(4) Allow the battery to remain idle for several minutes before rechecking the electrolyte level. Add only electrolyte and no water if the level is low.

(5) After the battery has been put into service, if it should need more liquid, use only approved water, not acid.

b. Wet Charged Batteries - These batteries contain fully charged elements which are filled with electrolyte when they leave the factory. While the wet charge battery is in storage, even not in use, a slow reaction will take place between the chemicals inside the battery and it will lose its charge. This is called self-discharge. The discharge rate depends a lot on the temperature. If at all possible, wet charge batteries shoild be left in a cool place, as this will help retard discharge. Also a periodical recharge will help keep up the storage battery.

If sulfated wet charged batteries are stored for long periods of time and not recharged, they may become permanently damaged by the oxidation of the positive plate grid and the formation of lead sulfate crystals in the plates. If the crystals of sulfate are not too dense and hard, the battery may be restored to service by a slow charge for a long time. But if the crystals of sulfate are hard, it can never be restored to normal operating condition.

Transparency No. 1

3. Testing the Battery

Testing will tell whether the battery is usable, requires recharging, or if it should be replaced.

a. Visual Inspection - Many things can be noted with a visual inspection. The battery may be damaged due to looseness or excessive tightness of hold down clamps. Distorted, cracked, or leaky case, broken cell vent caps, spilling or overflowing electrolyte, or heavy dirt deposits on the case can all contribute to battery failure.

b. Specific Gravity Tests - The state of charge of a battery is indicated by the specific gravity or the weight of the electrolyte. To find how much energy is available from the battery, the percent of sulfuric acid remaining in the electrolyte must be known. The easy way to do this is to measure the weight, or specific gravity, of the solution. This is done by the use of a battery hydrometer with a thermometer for making a temperature correction. The hydrometer is set to measure specific gravity of an electrolyte with a temperature at 80 degrees F. Add four gravity points to the hydrometer reading for each 10 degrees above 80 degrees F. Four gravity points (0.004) are subtracted for each 10 degrees below 80 degrees F. Handle the hydrometer in the following manner:

(1) Squeeze the bulb and insert nozzle in cell, then release the bulb to draw in electrolyte.

(2) Hold the hydrometer in the vertical position and see if float rides free before reading scale.

(3) Return electrolyte to cell, being careful not to drop acid, then flush hydrometer with clean water.

Example: The reading is 1.236 at 100 degrees F. The temperature of the electrolyte is 20 degrees or 0.008 specific gravity points above standard. The correct reading is 1.236 + .008 = 1.244. If the reading had been the same but the temperature was 70 degrees F., the reading would be 1.236 - .004 = 1.232.

Each cell must be checked when using a hydrometer. A variation between the cell readings should not exceed .050. The range of the specific gravity must be between 1.215 and 1.270 at 80 degrees F. However, a slight variation below 1.215 and above 1.270 may mean that the battery only needs conditioning to correct the reading. Usually where there is a difference of .050 volts between the cells the battery needs replacing.

c. Light Load Voltage Test - This test is used to check the voltage in each cell. The test is made by using the following steps:

(1) Add distilled water to bring the electrolyte to the same level in all cells.

(2) Operate the starter for three seconds to remove the surface charge. The engine should not be allowed to run.

(3) Turn on the head lamps to place a light load on the battery.

(4) Use a voltmeter to check the voltage of each cell. Wait one minute before starting the checking step. Steps in taking the reading are:

(a) Press the rigid prod point on dial into positive post and the other lead into a negative post.
(b) Observe the reading on the meter. The cell connector is considered positive when testing one cell and negative when testing an adjoining cell.

(5) The method used for interpreting the cell voltage readings is as follows:

(a) The battery is adequately charged if the cells read 1.95 or more with a difference in reading below .050.
(b) The battery needs charging if the reading is below 1.95 and any one cell exceeds .050 volts above another cell.
(c) The battery should be replaced if the reading is above 1.95 and any one cell exceeds .050 volts above another cell.

d. Discharge Test - The specific gravity test is used to check the discharge performance of a battery. Steps for making this test include:

(1) Connect the high-rated discharge tester to the battery terminals. Discharge the battery 20 seconds before taking the reading. A 12-volt battery is considered in good condition if the reading is 9 volts. A 6-volt battery should show 4.5 volts. A battery that does not measure up to the desired voltage should be charged and retested. It should be replaced if it does not hold the charge.

(2) Individual cells are tested by using a high-rated discharge tester and a low-reading voltmeter. Place the prods of the tester (Voltmeter) on the positive and negative terminals to make the test. If there is a difference of .20 volts between the readings of the two cells, the battery should be replaced.

4. The meaning of Battery Capacity

The two major ratings for storage batteries are:

a. Lighting and Accessory Load Capacity - This rating is made by testing the battery in the laboratory with the battery fully charged at 80 degrees F. The battery is discharged for 20 hours and must have an average cell test of 1.75 volts at the end of the period. This test is equivalent to 10.5 volts for a 12-volt battery and 5.25 volts for a 6-volt battery. The rate of ampere discharge gives the ampere-hour capacity of the battery. Example: 3 amperes x 20 hours = 60 ampere-hours.

b. Cranking Load Capacity - This test rating is made on a fully charged battery at 0 degrees F. with the amperes at a constant rate of 150 to 300, depending upon the ampere-hours and voltage of the battery being tested. The rating may be indicated by a 5 or 10 second discharge. A 12-volt battery will maintain a voltage of 7.6 for 10 seconds, if it has a voltage rating of 7.6 at 300 amperes at 10 seconds.

Transparency No. 2

5. Factors Affecting Battery Life

Neglect and abuse will shorten battery life, while periodic service has a very good effect on battery life. Cleaning of the battery cable clamp, posts, and tap are needed regularly. There are four key factors in long battery life.

a. Electrolyte Level - Underfilling and overfilling the battery will shorten its life.

(1) Underfilling will cause the electrolyte to become too concentrated, which will make the plate deteriorate more rapidly. The exposed tops of the plates can harden and become chemically inactive.

(2) Overfilling will cause the electrolyte to spill over, causing corrosion on the battery parts and cell covers. The correct level of electrolyte is above the tops of the plates, which is usually to the bottom of the filler neck.

b. Overcharging - Overcharging will cause a loss of water in the cells by separating the electrolyte into hydrogen and oxygen. The gas will work the active materials from the plates and will reduce the capacity of the battery.

c. Undercharging - An undercharged battery will become sulfated. The sulfate will become hardened and chemically irreversible if left in this state - the lower specific gravity level will render the battery more susceptible to freezing.

d. Cycling - A cycle consists of discharge and a recharge. Heavy and repeated cycling will tend to shorten the battery life. The active materials of the positive plates will shed and fall to the bottom with this cycling.

Other factors affecting the life of the battery are:

Hard Water - Never use hard or mineralized water. Clean, distilled water is recommended.

Corroded Cables and Terminals - Cables and terminals should be cleaned periodically. Connections must be tight and grease applied at the terminals.

6. Recharging a Storage Battery

Batteries become discharged through long use and abuse and through defects. When a battery is in use, the current flows from the positive (+) terminal through the circuit and back to the negative (-) terminal. Current flows in the opposite direction within the battery. During recharging, current in the battery flows in the opposite direction from when it is in use.

a. The steps for preparing a battery for charging include:

(1) Wash dirt and acid from the battery by using baking soda and water. Rinse with water.

(2) Remove film from terminals with a piece of sandpaper or wire brush and lubricate with light grease.

(3) Check the liquid level in the terminals. If it is necessary to remove some of the electrolyte to prevent overflowing when charg-

ing, return it to the cells after the battery is charged.

(4) Extremely cold batteries should be warmed before adding water due to the level of the electrolyte rising when being charged.

b. The steps to follow in charging a battery by either fast or slow charge are:

(1) Connect the charger positive lead to the battery positive terminal and connect the negative lead to the negative terminal.

(2) If the battery has been discharged rapidly, recharge with fast charge (rate of 40 to 70 amperes from 1 1/2 to 3 hours, depending on size and type of battery). If the battery has been discharged slowly, recharge with slow charge (normal period is 12 to 24 hours). Batteries that are highly sulfated may require 60 to 100 hours to recharge.

(3) Recharging amperes for a 12-volt battery should not exceed 40, and a 6-volt battery should not receive over 80 amperes during recharging. The electrolyte should not be heated more than 120 degrees F.

(4) Full charge the fast charged battery by following with a slow charge. The charging rate is one ampere for each positive plate per cell.

(5) Check the level of the electrolyte in each cell after charging the battery.

7. What Happens in the Battery

a. Electricity is created by chemical action. Iron in the water will discharge both positive and negative plates. Copper in the battery water will discharge the negative plates. High temperatures will damage all the plates. A battery will become sulfated if it is allowed to sit discharged for a long period.

b. A run-down battery can be easily charged, if it has not been sitting in a discharged condition. Acid is added after a battery is fully charged. The gas given off when charging a battery is explosive. Continuous overcharge will ruin the positive plates.

c. Approved water should be added to the electrolyte. If the specific gravity is 1.280 the electrolyte will freeze at 90 degrees below zero. Water is manufactured by the positive plates when current is used. The plates should always be covered with electrolyte.

8. Safety Rules to Follow When Handling Batteries

   a. If acid is spilled on clothing, remove it immediately and wash the skin area with water for about 10 minutes.

   b. If any acid enters the eyes wash them about 10 minutes with running water. Do not use medication. Report to a doctor.

   c. If acid is spilled on the floor, neutralize it by mixing a pound of baking soda with water and pouring over the area. Rinse the area with water after the signs of acid disappear. A pint of household ammonia in one gallon of water may be used to remove the acid.

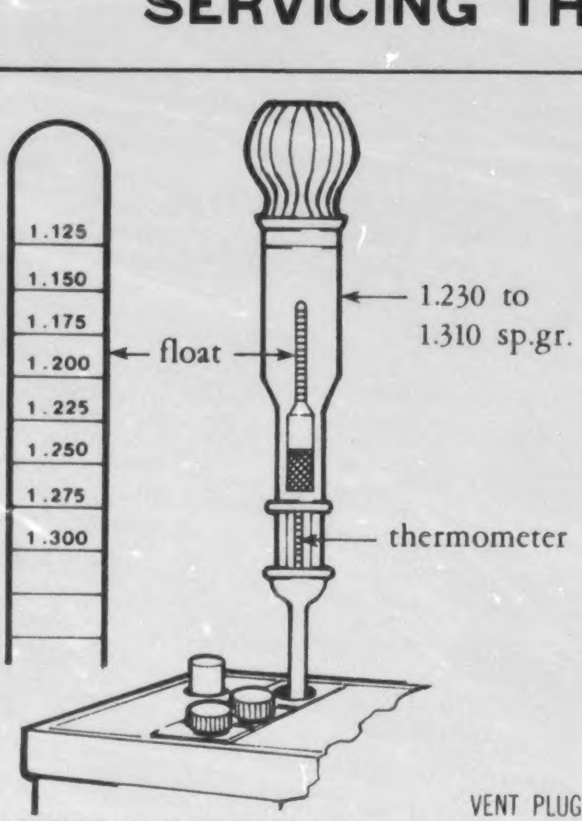
References:

1. Promersberger, William J., and Others, Modern Farm Power, Prentice Hall, Inc., Englewood Cliffs, New Jersey, 1971

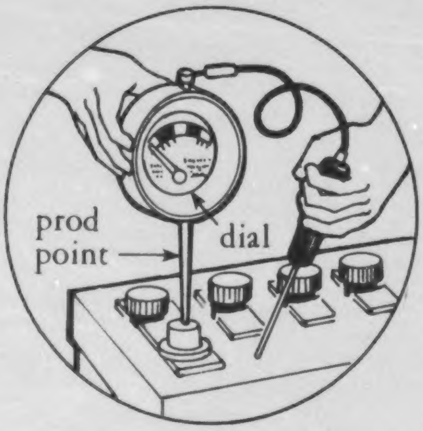
2. "The Storage Battery", University of Illinois, Vocational Agriculture Services, Urbana, Illinois, 1970

3. "Fundamentals of Service - Electrical Systems", Deere and Company, Moline, Illinois, 1973

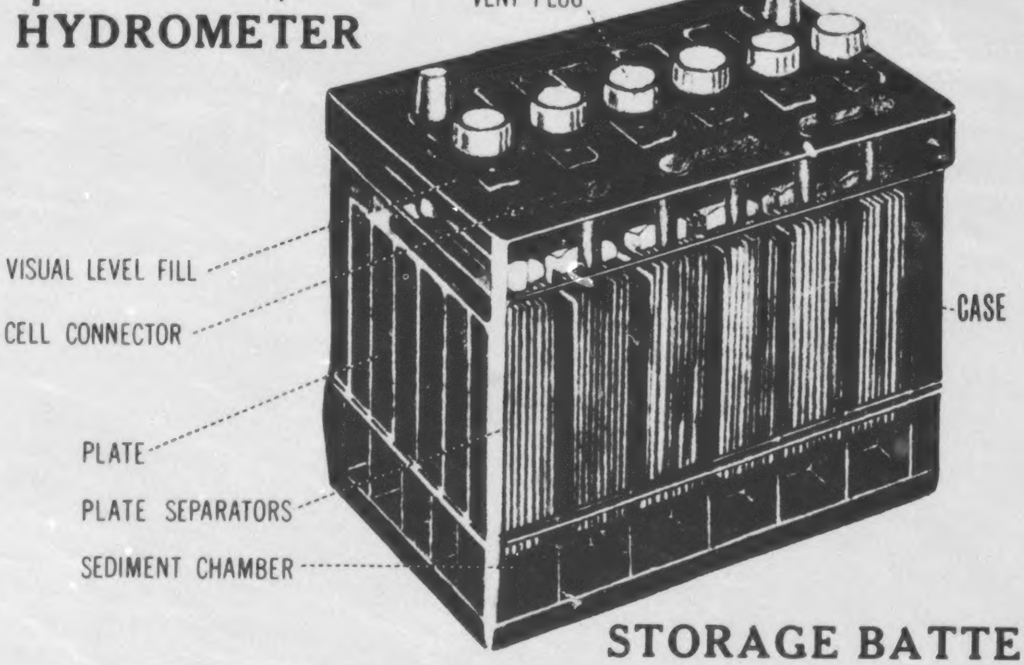
SERVICING THE BATTERY


1.125
1.150
1.175
1.200
1.225
1.250
1.275
1.300
float
1.230 to
1.310 sp.gr.
thermometer

HYDROMETER

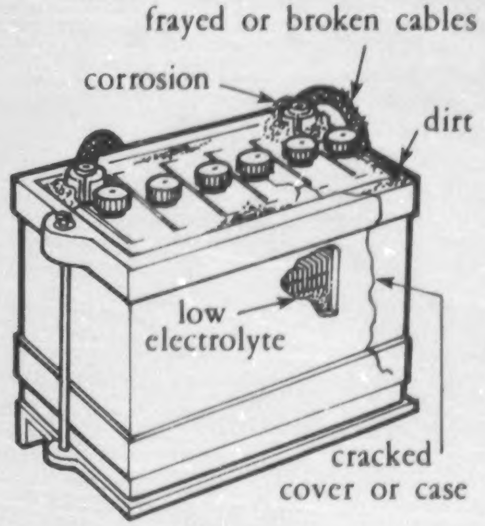

prod
point
dial

VOLTMETER

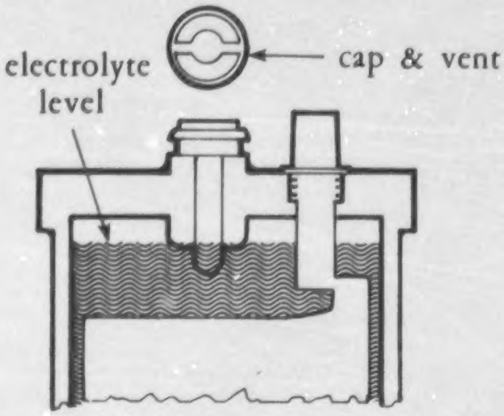

TERMINAL POST
VENT PLUG
VISUAL LEVEL FILL
CELL CONNECTOR
CASE
PLATE
PLATE SEPARATORS
SEDIMENT CHAMBER

STORAGE BATTERY

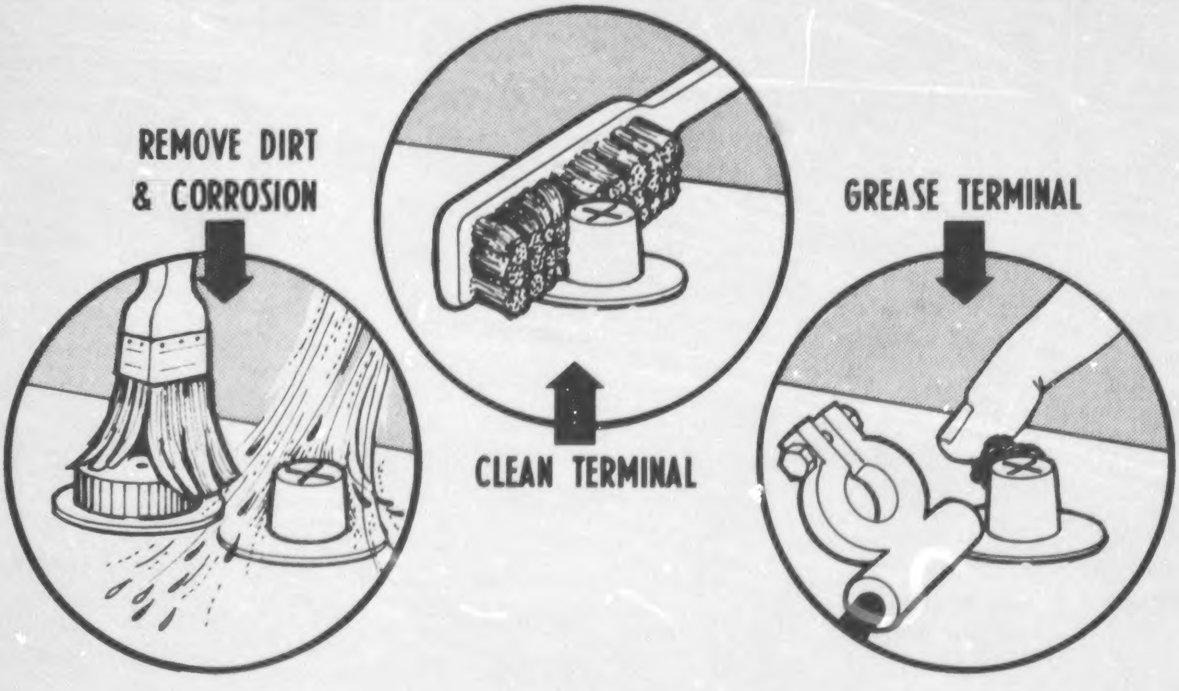
CARE OF BATTERY


frayed or broken cables
corrosion
dirt
low electrolyte
cracked cover or case

BATTERY LIFE FACTORS


electrolyte level
cap & vent

PROPER ELECTROLYTE LEVEL


REMOVE DIRT & CORROSION
CLEAN TERMINAL
GREASE TERMINAL

GENERAL AGRICULTURAL MECHANICS

Unit C: Servicing the Electrical System

Topic 2: Cleaning and Adjusting Spark Plugs

Suggested Procedures and Activities: Distribute to each student an old spark plug during the class discussion. Review the condition of each plug and name all visible parts.

1. General Spark Plug Information

Farm tractors and other types of powered machinery that are of the spark-ignition type rely on spark plugs that provide a hot constant spark that assures the best use of fuel in the combustion chamber, resulting in maximum power, easier starting, and maximum acceleration. All modern spark plugs are designed to give utmost efficiency, last for many hours of operation, and provide adaptability to various heat ranges.

The two important functions of the spark plug are to provide a pair of electrodes between which the electric current is pushed by high voltage (10,000 to 20,000 volts) forming a spark to ignite the fuel mixture, and it conducts this high tension electric current from other parts of the ignition system into the combustion chamber. This high voltage that causes the spark to jump the gap on the ground electrode side is produced in the secondary winding of the coil.

2. The Reasons Why It Is Important to Maintain The Spark Plug

a. Horsepower decreases and fuel consumption increases with the age of the plug. Misfiring is one of the main causes of loss of horsepower and increase in fuel use.

b. Less voltage is required to force the spark across the electrode gap on good plugs. As the plug becomes worn by hot combustion gases and continuous electrical discharge, the electrode edges are rounded and the spark gap increases. For example, it is not uncommon for a gap to increase .001 inch for each 20 hours the engine is in operation. If the engine operates about 200 hours a voltage of 15,000 may be required to make the plugs useful. When spark plugs can no longer be adjusted to maintain a square relationship between the electrodes, then they should be replaced. In some engines this may mean 250 operating hours.

3. Kind of Spark Plugs to Use

a. The kind of plug to use can be determined by the engine operator's manual and the manufacturer's spark plug chart. The main factors that affect the size and kind of plug for a specific engine are as follows:

Transparency No. 1

(1) Load Operation - Plugs are made for normal hot and cold operation conditions. Hot and cold means the difference in temperature at which the plug will operate inside the combustion chamber. Cold plugs are used in engines operating under heavy loads, where the engine operates hot. If hot plugs are used under heavy loads, the following conditions may be encountered:

(a) Plugs overheat causing the insulator tip to blister.
(b) Electrodes burn and erode.
(c) Lead forms on the plug.
(d) Engine knocks which is caused by the preignition of the fuel mixture before the plug fires.

Transparency No. 1

(2) Engine Design - Plugs must be the proper length for the engine head. A plug that is too long may be struck by a piston and the firing time may be incorrect. One that is too short may shield the spark and expose spark plug threads to corrosion. Heat can escape through the insulating material, plug shell, gasket, and threads to the cylinder head when using a plug that is too short.

(3) Type of Fuel - The type of fuel used will regulate the type of plug to a certain extent. For example, changing from gasoline to L. P. gas may require a colder plug or the changing from gasoline to distillate may require a hotter plug to keep carbon cleaned off the plug.

4. Servicing Spark Plugs

Transparency No. 1

a. Removing and inspecting a spark plug is a simple operation if plugs are accessible with common spark plug tools. These steps are:

(1) Use a deep socket wrench and loosen each plug one or two turns. Use a special spark plug socket that is rubber lined.

(2) With air nozzle, blow dirt away from each plug or start the engine and run it for a few seconds to remove dirt.

(3) Place each plug in order as they are taken from the engine. The plug can be identified with the cylinder which may identify special cylinder problems.

b. Spark plugs are inspected for abnormal conditions. Usually the mechanic can make a correct diagnosis of spark plug failure by removing the plug and observing its condition. Some engine problems such as overheating, oil use, using too much fuel, and misfiring can be detected by the condition of the spark plug. The observation can be made using the condition chart:

Transparency No. 1

CONDITION CHART

Condition	Cause
NORMAL Very slight electrode wear, brown to grayish deposits. Can be cleaned and regapped.	Correct spark plug heat range and proper engine load and speed. Use proper fuel.
CARBON FOULING Dry, black carbon deposits. Can be cleaned and regapped.	Overrich carburization, cold plug, faulty choking, dirty air cleaner, weak ignition, and faulty fuel pump.
OIL FOULING Wet, oily deposits and little electrode wear. Can be cleaned and regapped.	Oil entering combustion chamber by passing worn rings. Large amount of clearance between valve guides

	and stems or defective intake valve seals.
GAS FOULING Dry, black fuel carbon deposits. Can be cleaned and regapped if insulator is not heavily coated.	Too rich air-fuel mixture; defective ignition wiring, coil or breaker points. Dirty air cleaner, stuck heat riser, and excessive choking.
EXCESSIVE OVERHEATING Burned or blistered insulator tips and badly worn electrodes. Install new plugs after problem is corrected.	Preignition or improper timing causes engine to overheat; hot spark plugs, wrong fuel-air mixture, wrong type of fuel, defective fuel pump (pressure), and stuck closed heat riser valves.
SCAVENGER DEPOSITS Powdery deposits (white, red, brown, and yellow). Engine misfires at high revolutions. Lead is white powdery deposit. Hard silicone deposit is usually hard and scratchy. Replace spark plugs.	Combustion of fuels containing additives. Dirty air cleaners will cause deposits, also cold plugs. Highly leaded gasoline - lead deposits. Formed as sand particles unit with anti-knock compounds.
SPLASHED FOULING Splotchy deposits on insulator. Clean and regap before reinstalling.	Deposits formed after a long period of misfiring. Engine operating at high speed throws deposit into the plugs. New plugs are affected after a long delayed tuneup.
RAPID GAP WEAR Both electrodes worn. Install spark plugs that are one step colder.	Engine operating under excessive load or the plugs are too hot.

Transparency No. 2

c. Use an approved cleaner or solvent to remove carbon, oil, and oxide coatings from the firing end of the plug. Use a cloth and solvent to clean the insulator top and terminal. It is a good practice to wash the plug in a solvent and dry it before attempting to clean certain parts. Hard deposits can be removed with a small knife. File the electrodes with a flat distributor point file. Filing squares the electrodes and removes the oxides. Clean the spark plug threads with a hand or power wire brush. Blow metal filings from the plug and rinse again in solvent. Plugs may also be cleaned in a cleaning machine.

Transparency No. 2

d. Regap the plugs as recommended by the operator's manual or plug specification chart. Use a round wire gauge to check the gap. The ground electrode cannot be gauged accurately with a flat gauge. Always bend the ground electrode to the desired gap.

e. When the majority of the plugs in an engine are worn out, it is advisable to replace the entire set. Plugs with cracked or broken insulators, burned, pitted, or worn electrodes should be replaced. If a plug appears to have a short life, replace it.

Transparency No. 3

f. The spark plug is made up of the following parts:

- Terminal
- Insulator
- Shell
- Center electrode
- Rib
- Reach
- Grounded electrode
- Wrench flats
- Gasket
- Seals
- Threads
- Spark gap

g. When reinstalling spark plugs, it is important that the area around the post is clean. Plugs are cooled by the coolant that circulates through the engine head passages. Steps in replacing a plug include:

(1) Unless the plug has a tapered seat, use a gasket and tighten it with the fingers.

(2) Use a spark plug socket and torque wrench if possible to tighten plug. Use the operator's manual for the pounds of torque to apply. A plug that is properly tightened will transfer about 50 percent of the heat to the engine head.

(3) Wipe the insulators and terminal with a clean cloth, check the spark plug wires for cracks and softness, and replace defective wires.

(4) Before pressing the connectors on the plug terminals check the polarity by holding the connector about 1/4 inch away from the plug terminal. Position a pencil point between the terminal and connector. Turn the engine to see if the spark feathers with a slight orange color on the plug terminal. If it feathers against the connector, change ends with the spark plug wire. If the polarity is incorrect too much voltage is necessary to fire the plug.

(5) Press the plug connectors on the terminal nuts and check for looseness. Loose connectors allow corrosion and arcing.

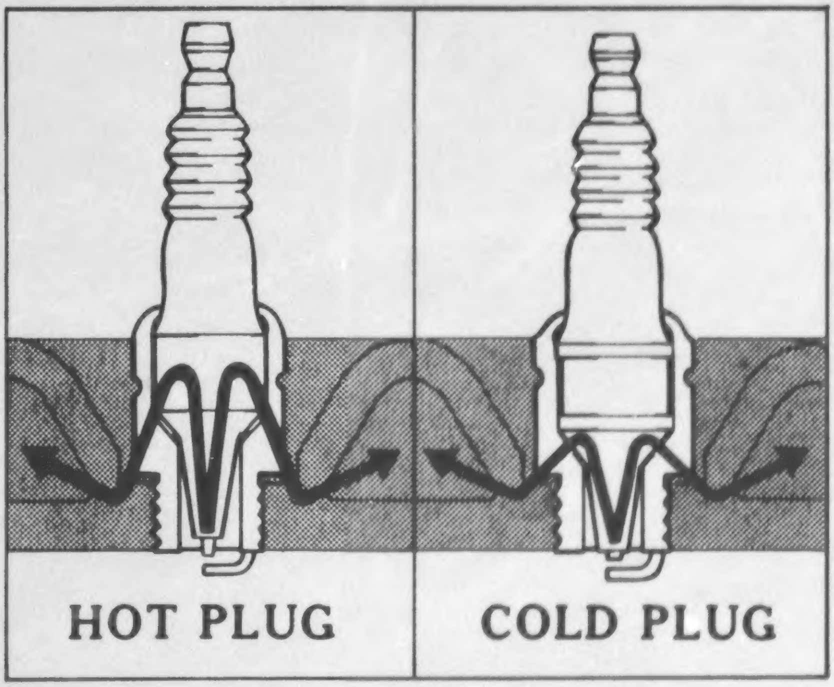
References:

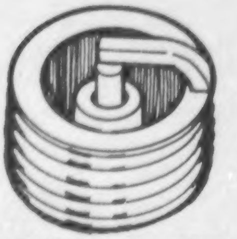
1. Stockel, Martin W., Auto Service and Repair, The Goodheart-Willcox Company, Inc., South Holland, Illinois, 1969

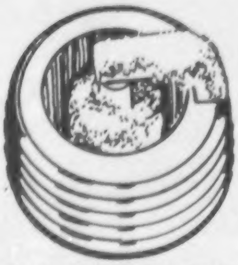
2. "Fundamentals of Machine Operation - Preventive Maintenance", Deere and Company, Moline, Illinois, 1973

3. "Tractor Maintenance - Principles and Procedures", American Association for Vocational Instructional Materials, Athens, Georgia, 1975

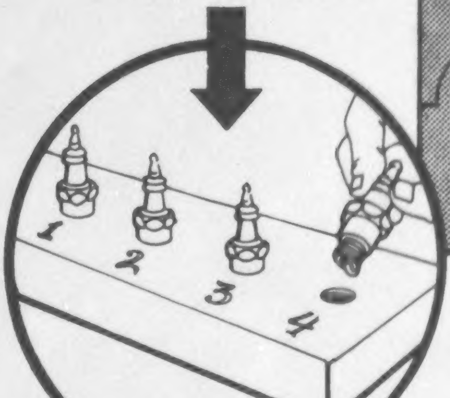
SERVICING SPARK PLUGS

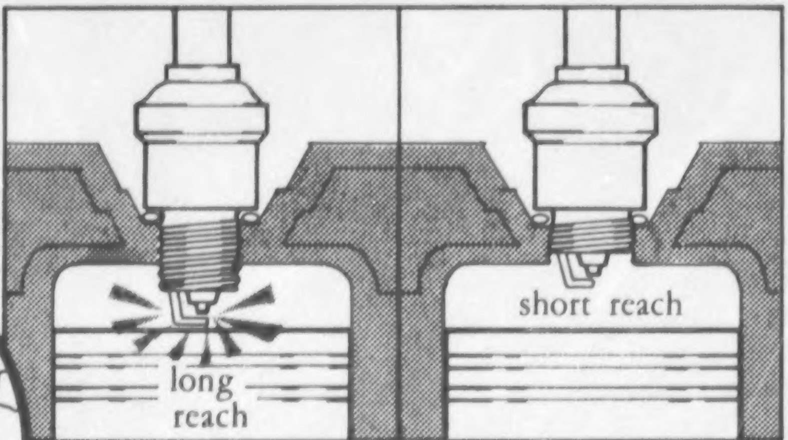

HOT PLUG
COLD PLUG


NORMAL PLUG


SCAVENGER DEPOSIT

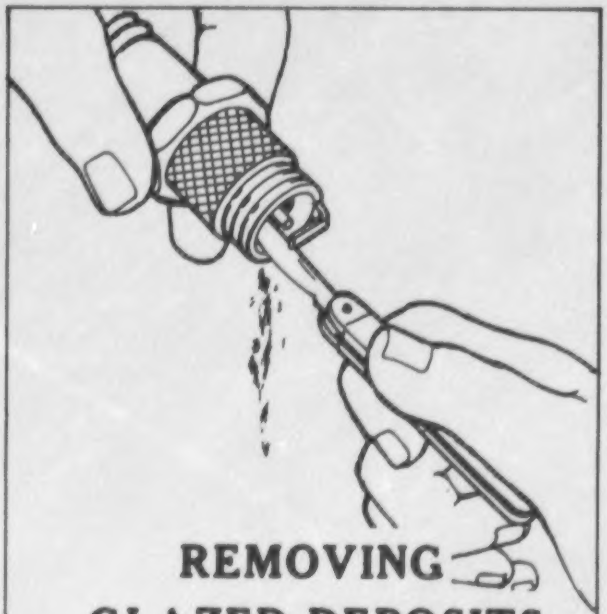
ORDER OF REMOVAL



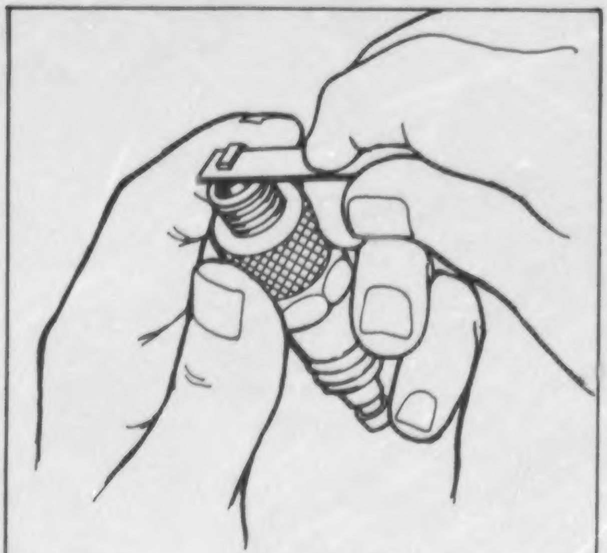

long reach
short reach

IMPROPER PLUG REACH

SERVICING SPARK PLUGS



REMOVING GLAZED DEPOSITS



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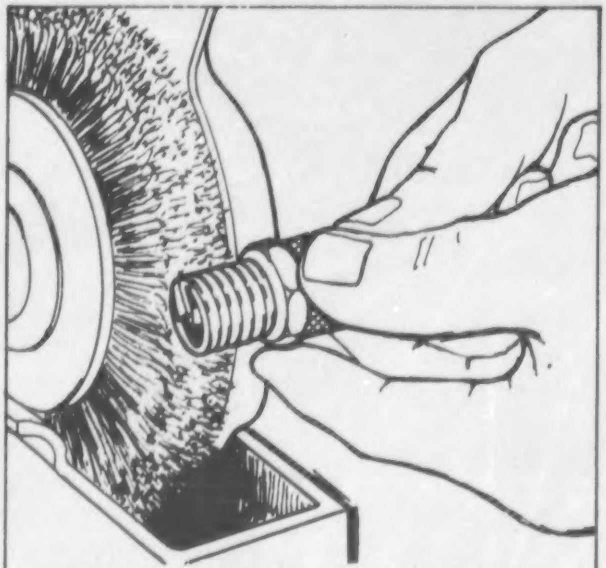
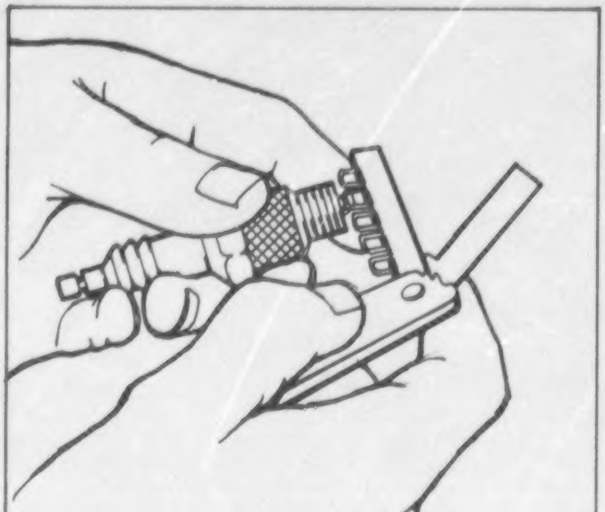
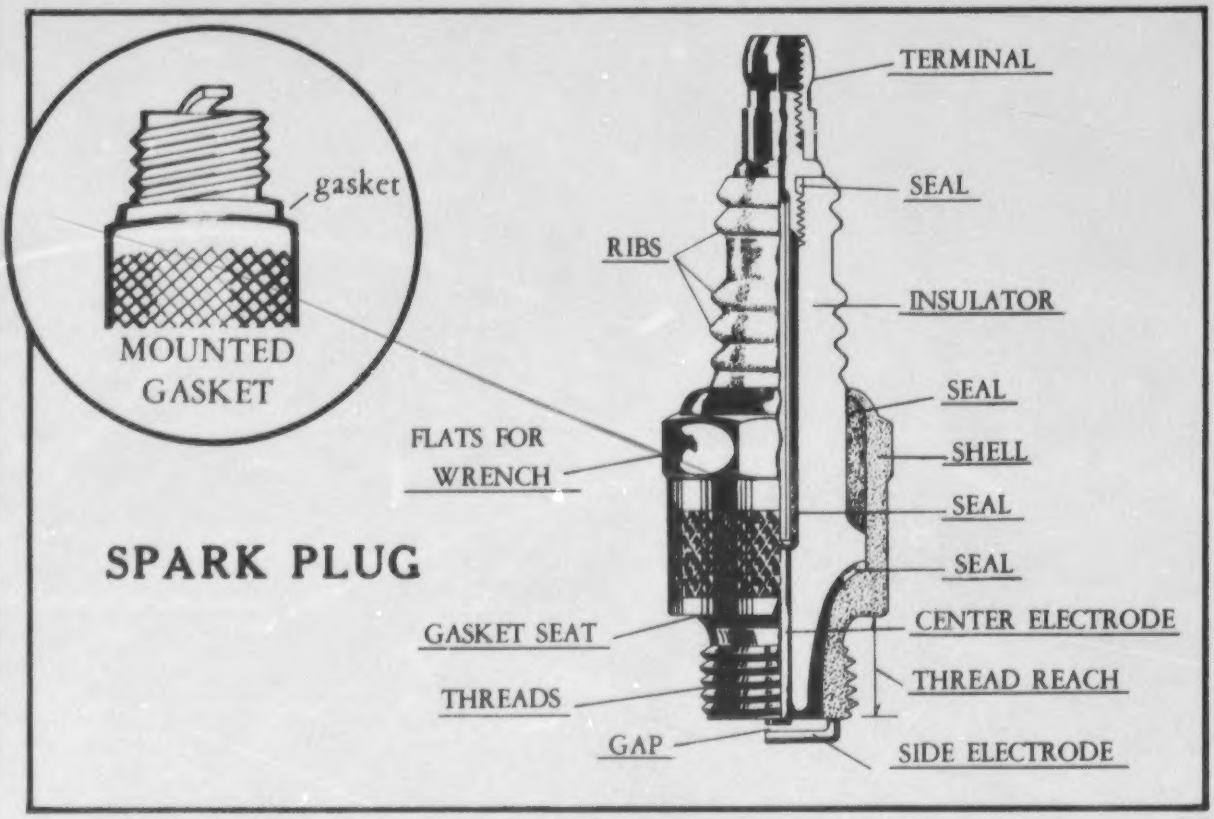


BRUSHING THREADS



ADJUSTING GAP

SERVICING SPARK PLUGS


gasket
MOUNTED GASKET
TERMINAL
SEAL
RIBS
INSULATOR
SEAL
FLATS FOR WRENCH
SHELL
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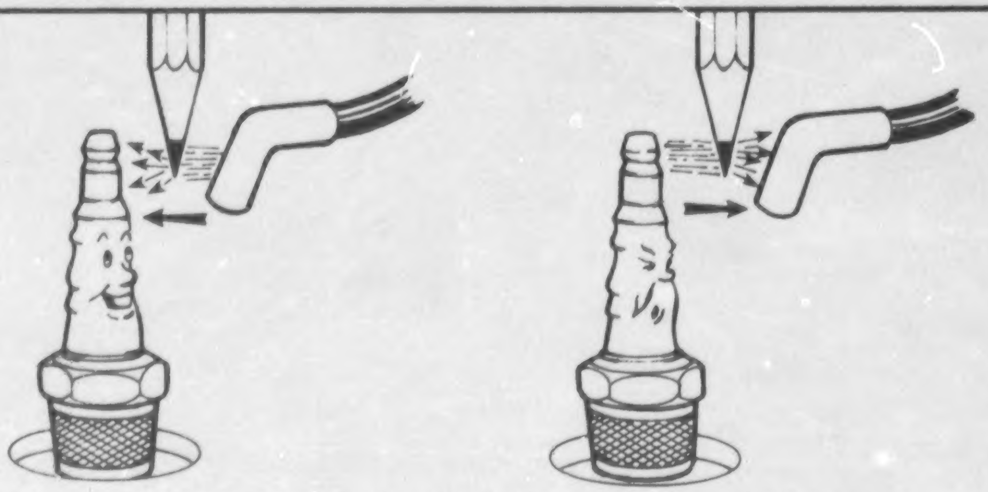
SEAL
GASKET SEAT
CENTER ELECTRODE
THREADS
THREAD REACH
GAP
SIDE ELECTRODE

SPARK PLUG



POLARITY AT PLUG TERMINAL

GENERAL AGRICULTURAL MECHANICS

Unit C: Servicing the Electrical System

Topic 3: Servicing the Distributor and Its Components

Suggested Procedures and Activities: Use a distributor with all its parts as a teaching aid during the class discussion. Also, the transparencies may be used along with the distributor.

Transparencies Nos. 1a and 1b

1. The Purposes of the Distributor and Related Parts

    a. Ignition Distributor - The main parts of a distributor are: the cap, rotor, breaker cam, condenser, breaker points and arm, breaker plate, advance mechanism, and drive shaft.

    As the breaker cam is turned by the shaft, the lobes on the cam push the breaker lever on the breaker arm, opening the points and stopping current flow.

    As the field collapses a high voltage surge from the coil's secondary winding forces current into the distributor cap central terminal. Current is picked up by the rotor and is delivered to the spark plugs.

    The advance mechanism in the distributor times the spark to engine speed. It is very important that the spark be delivered when the piston is in the proper position in the cylinder. A vacuum advance is usually used in conjunction with a centrifugal advance. If a vacuum develops in the manifold, causing a lean air-fuel mixture to enter the cylinder, ignition must take place earlier, because the lean mixture will burn slower. The centrifugal advance consists of two weights in the distributor which throw out against spring tension to advance the breaker cam as engine speed increases. The spark timing varies from no spark advance at idle speed to full advance at full speed.

    b. Condenser - The condenser is made of two strips of tin foil wound together to form a cylinder. The foil is separated by insulating strips of high quality wax paper. The condenser absorbs the electrical energy that could arc across the breaker points and burn them. The condenser charge is higher than any other part of the primary circuit. The lack of a condenser would permit the current to continue to flow from the coil with the points open. The flow would be in the form of an arc between the points and then to the ground. With the condenser in operation, the current passes from the coil to the breaker points, condenser, and then to the ground. This direction of current flow occurs when the points are open. A bad condenser should be replaced. It is not repairable. It is usually found in the distributor.

c. Breaker Points - These points control the opening and closing of the primary circuit when the engine is operating. When the points are closed and the switch is on, current flows through the primary circuit. This action produces a strong magnetic field in the iron core. As the breaker points open, the current continues to flow, creating a small arc across the points. The condenser stops this arc action provided by the points and furnishes a place for the current to flow, which causes a quick collapse of the magnetic field and induces high voltage (up to 22,000 volts). This high voltage in the secondary circuit permits it to jump the spark plug gap causing spark. The points may be considered as a switch in the distributor.

d. Ignition Coil - This coil has two types of windings: secondary and primary. A soft iron core is located in the center of a metal container. The core is wrapped with a fine wire (secondary winding) which is connected to the high tension terminal. The heavy wire (primary winding) is wrapped around the light wire. The ends of this wire are attached to the primary terminals in the coil. The coil windings are sealed in the container either with insulated material or oil. A coil that functions improperly should be replaced. The coil is the transformer of the electrical system. It increases the voltage from the battery.

e. Primary and Secondary Wires - The primary (low voltage) wires carry the current from the battery to the switch and coil. Secondary (high voltage) wires are found extending from the coil to the top of the distributor and from the distributor to the spark plugs. The spark plug wires are also referred to as cables. Both leads from the battery terminals are called cables.

f. Ballast Resistor - Most of the 12 volt battery ignition systems on farm machines have a ballast resistor that is located between the switch and coil. Its purpose is to protect the distributor points when the machine is running slow and to protect against the buildup of a primary current when the engine is stopped and the points are closed.

Transparency No. 2

2. Checking the Distributor and Related Parts

a. The Distributor -

(1) Check the distributor cap for burns and cracks. Damaged caps should be replaced. Wash all parts to free them of dirt and grease. A soft rag dipped in kerosene makes a good cleaner for a distributor. A special solvent may also be used. Wipe dry with clean cloth. Wipe the inside with a dry clean cloth. Check inside cap for carbon paths. Replace the old cap with a new cap if these paths are found.

(2) If it is necessary to remove the spark plug cables, they should be removed, inspected, cleaned, and replaced one at a time.

(3) Inspect the distributor rotor. It receives the high voltage current; therefore, it may be badly worn or burned, and the contact spring may be weak. A damaged rotor must be replaced.

(4) Turn the distributor shaft normally to check centrifugal advance mechanism. After rotating freely, it returns to the original position.

(5) Check the condition of the distributor breaker points. The points may be maintained by keeping them filed smooth; that is, if they are not burned and badly pitted. Set the points as recommended, grease the cam, and oil the felt pad. Check the points to determine whether or not a point has formed on the stationary breaker point and a pit formed on the other. This condition is caused by a condenser lacking capacity. If the condenser capacity is too high, a point will be formed on the breaker level point. Also check the alignment of + and - points.

(6) Check all spark plug wires for mechanical wear and defective insulation. These high tension wires may cause a voltage leak by grounding out the current. Weak voltage will cause a weak spark at the spark plug. The manual method used to test the distributor is to remove the lead from the spark plug and hold it 1/4 inch away from some metal part of the tractor engine. If a spark occurs as the engine makes its revolution, the distributor and wires should be functioning properly. Plug wire resistance should be checked with an ohmmeter.

The distributor is usually checked if the engine is hard to start, if the engine fires improperly, or if the engine uses an excessive amount of gasoline.

b. The Condenser -

(1) If there is doubt about the ignition voltage, check the condenser with a condenser tester or coil-condenser tester.

(2) Check for burned and pitted points. This is a good indication of whether the condenser is usable or should be replaced.

(3) Use the condenser tester to determine whether or not it is grounded or shorted or has low insulation resistance, high series resistance, or the proper capacity.

c. Breaker Points -

(1) First check the points for excess pitting and metal transfer. Normal points are a grayish color. If the points are burned or badly eroded, they must be replaced.

(2) File slightly worn points flat with a fine-cut file. Emery cloth must not be used. After filing remove dirt from points with a solvent.

(3) Check the breaker arm rubbing block for wear. A worn cam lobe or lack of lubricant may cause excessive wear. Worn or damaged breaker points should be replaced.

d. The Coil -

(1) Check the ignition circuit periodically for broken leads, loose connections, and cracked and broken parts. Damaged rubber nipples on the high-voltage circuits will cause leakage of current, and cracks will permit moisture which will cause the coil to function improperly.

(2) Check the coil tower for corrosion and burning. Remove the wire before making this high tension terminal check. Check for flashover (the high voltage current leaving the natural or normal flow pattern and leaping down). If flashover has cracked or damaged the top of the coil, replace it.

(3) Check the coil voltage by using the primary resistance test with an ohmmeter. The test will show shorts, grounds, opens, insulation breakdown, and corroded or loose connections. Current draw-

ing is checked with the engine idling and stopped.

(4) Check the coil polarity by grounding the positive voltmeter lead and passing the other lead over a spark plug terminal. The polarity is correct if the needle moves up.

(5) If grounding and open winding is not checked with a voltmeter, use two leads and a lamp to check the coil.

Transparency No. 3

3. Replacing and Adjusting Distributor and Related Parts

a. Installing Breaker Points -

(1) If the distributor is removed from the engine, mark the housing and rotor positions and remove the switch key in order to keep the engine from being cranked.

(2) Remove the breaker points by loosening or removing the proper screws. For example, one type is removed by removing the locking screw and lifting out the bracket with the points. The breaker point arm is disconnected at the primary terminal and the point is lifted from the pivot post. The breaker point bracket contains a locking and adjusting screw.

(3) Lubricate the cam with multi-purpose grease. It should be lubricated around the area where the rubbing block travels. If there is a felt gasket in the top of the cam, it should be lubricated with a few drops of SAE 20 oil.

(4) New points are installed by reversing the method for removing points.

b. Adjusting the Breaker Points -

(1) Rotate the cam until the rubbing block rests on the cam lobe. The points should be open at their widest position. This position is acquired by touching the starter slightly. Check the gap with a blade-type feeler gauge.

(2) Disconnect points by loosening locking screw on the bracket or to

adjust points loosen the locking screw on stationary bracket. Adjust the point spacing by using the adjusting screw or screwdriver slot found on the bracket. Improper gap can cause improper tuning, burned and pitted points, and a weak spark at a high rpm.

(3) Tighten the lock screw and check the gap again. Clean the surface of both points by using a rag or paper.

c. Cam Angle -

(1) The cam angle or better known as the dwell angle (degrees that the distributor cam turns from closing to opening of the breaker points) must be set to specifications. Check the cam angle with a dwell or distributor tester. Adjust the points to the dwell angle.

(2) Check for such problems as a worn breaker cam, point spring tension, proper point assembly, and bent drive shaft if the point gap and cam angle cannot be properly set.

References:

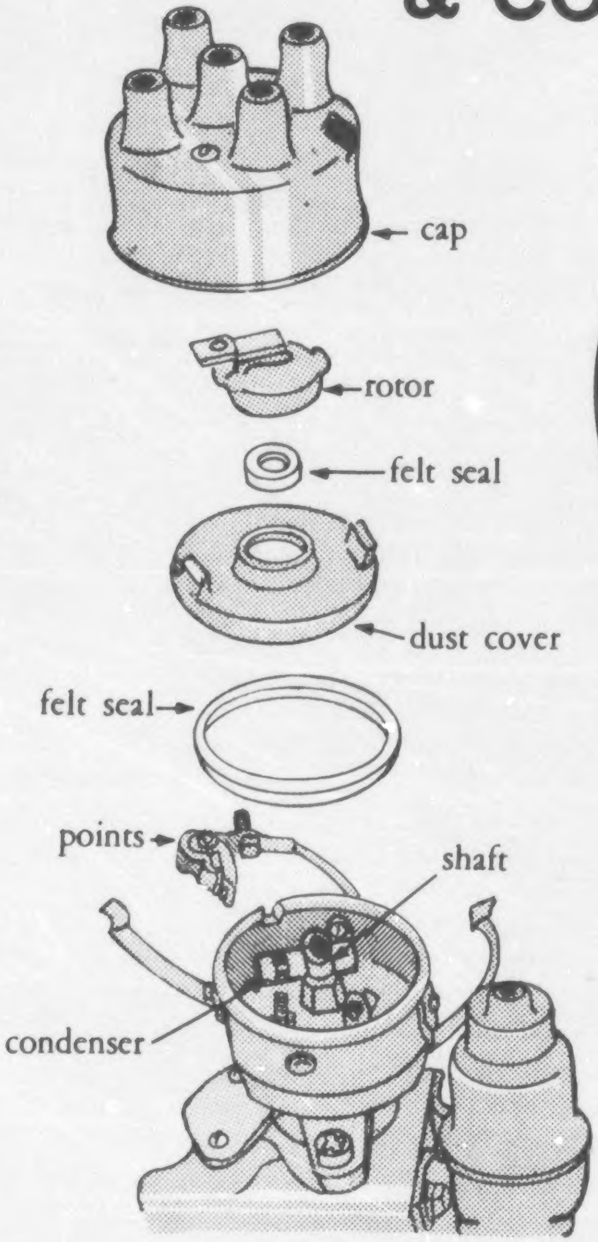
1. Stockel, Martin W., Auto Service and Repair, The Goodheart-Willcox Company, Inc., South Holland, Illinois, 1969

2. "Fundamentals of Machine Operation - Preventive Maintenance", Deere and Company, Moline, Illinois, 1973

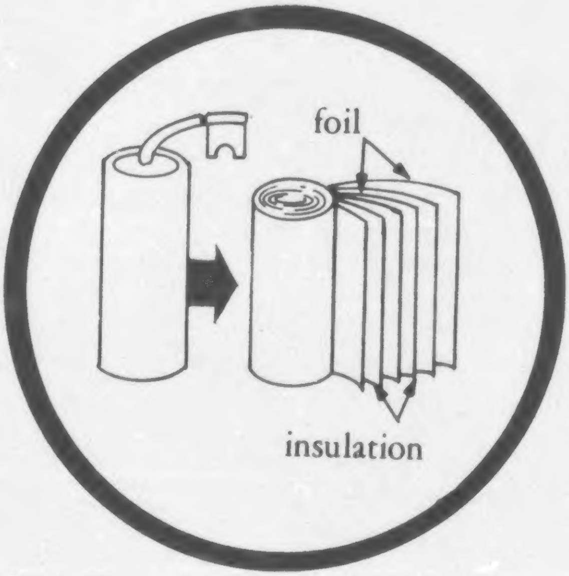
3. "Fundamentals of Service - Electrical Systems", Deere and Company, Moline, Illinois, 1972

4. "Tractor Maintenance, Principles, and Procedures", American Association for Vocational Instructional Materials, Athens, Georgia, 1975

DISTRIBUTOR & CONDENSER

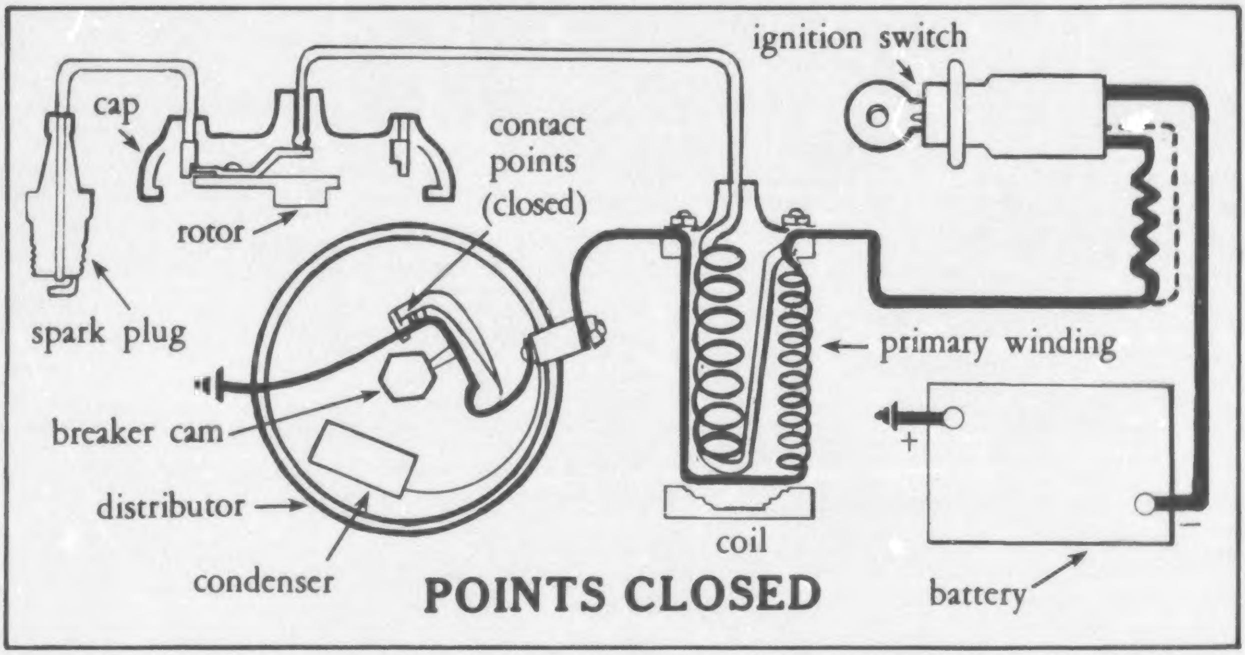

cap
rotor
felt seal
dust cover
felt seal
points
shaft
condenser

IGNITION DISTRIBUTOR

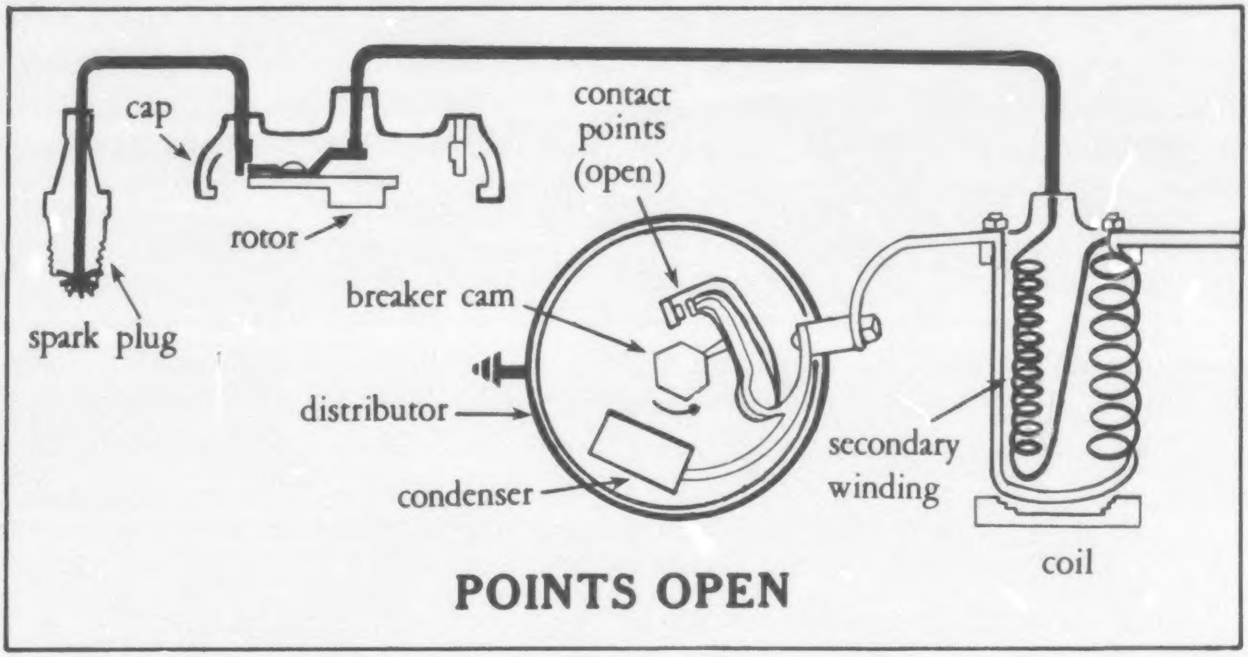

foil
insulation

CONDENSER

IGNITION CIRCUIT OPERATION

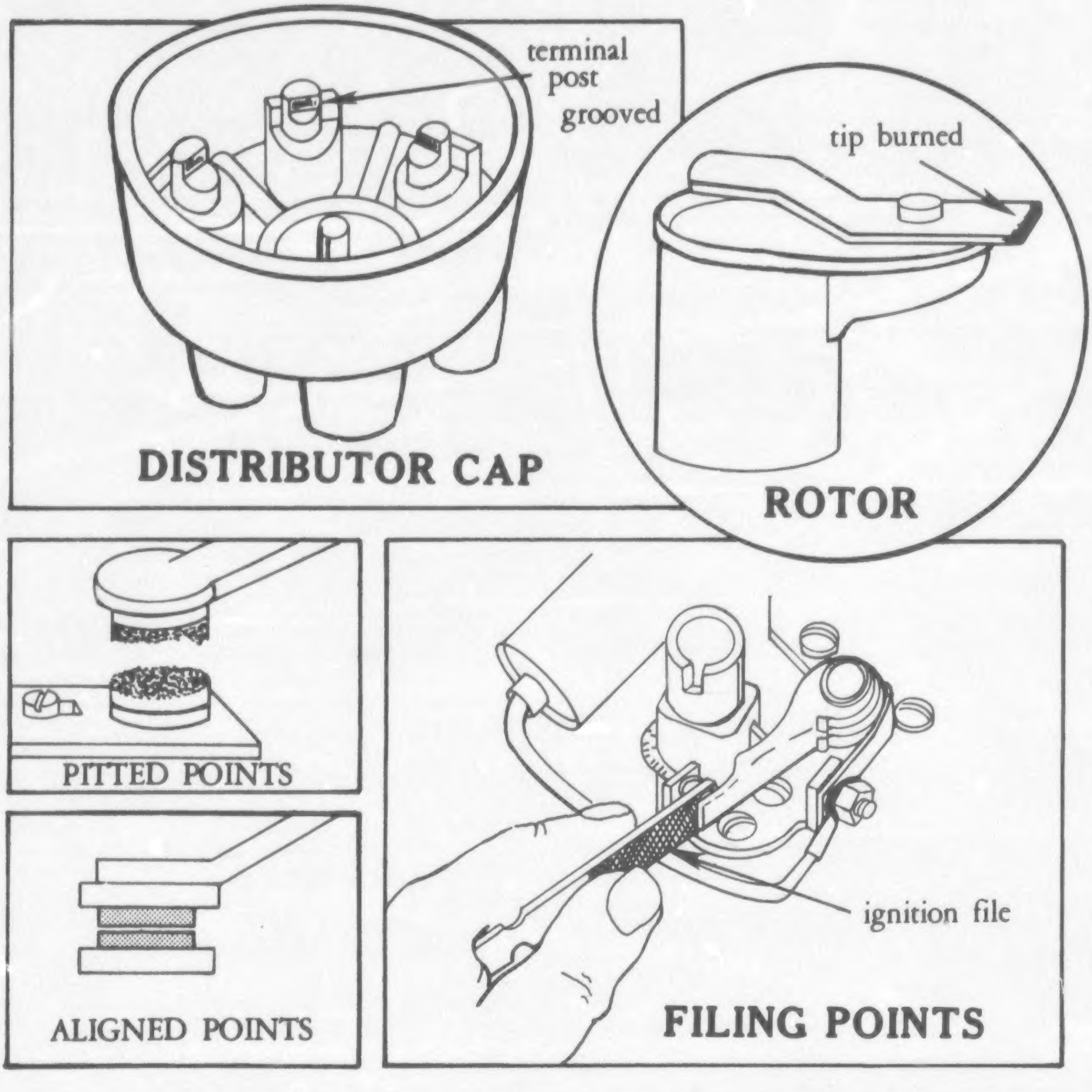

ignition switch
cap
contact points (closed)
rotor
spark plug
primary winding
breaker cam
+
distributor
−
coil
condenser
battery

POINTS CLOSED


cap
contact points (open)
rotor
spark plug
breaker cam
distributor
secondary winding
condenser
coil

POINTS OPEN

CHECKING THE DISTRIBUTOR & RELATED PARTS


terminal post grooved
tip burned
ignition file

DISTRIBUTOR CAP

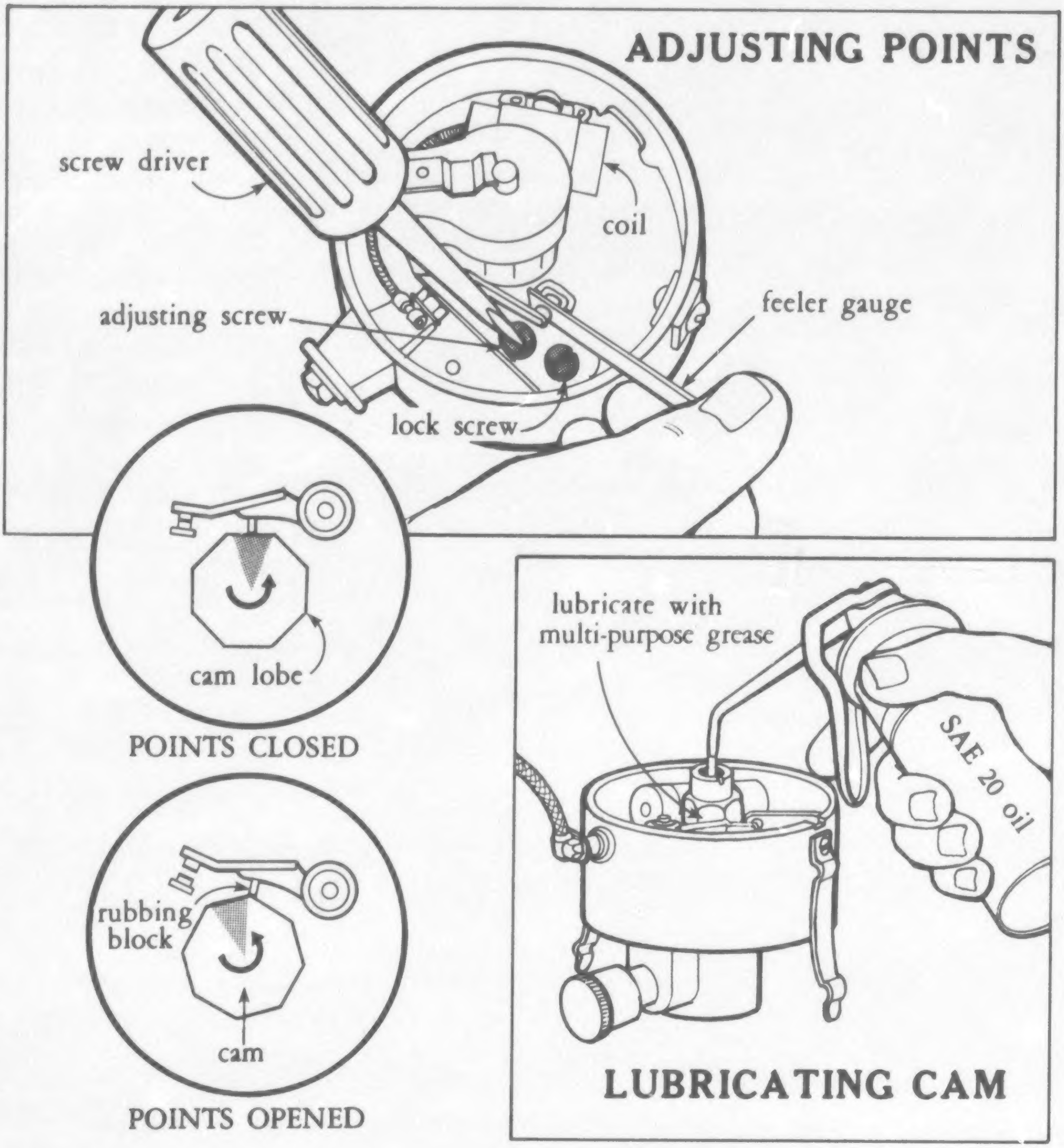
ROTOR

PITTED POINTS

ALIGNED POINTS

FILING POINTS

REPLACING AND ADJUSTING DISTRIBUTOR AND RELATED PARTS


ADJUSTING POINTS
screw driver
coil
feeler gauge
adjusting screw
lock screw
cam lobe
POINTS CLOSED
rubbing block
cam
POINTS OPENED
lubricate with multi-purpose grease
SAE 20 oil
LUBRICATING CAM

GENERAL AGRICULTURAL MECHANICS

Unit C: Servicing the Electrical System

Topic 4: Ignition Timing

Suggested Procedures and Activities: The use of a distributor with the points and condenser intact, a spark plug, ignition wire, and a coil may be used as teaching aids during class discussion. The feeler gauge and ignition file may also be used in class as aids.

1. The Meaning and Importance of Proper Engine Timing

Timing is the process of getting a spark to occur when the piston of the engine is in the proper position, just as it finishes its compression stroke. The spark occurs when the breaker points open. The thing that must be done in ignition timing is to get the proper relations of (1) the opening of the breaker points, (2) the position of the piston, and (3) the position of the distributor rotor. A retarded spark usually causes late firing which in turn lets gases escape while they are still hot. Not only is power wasted, but the exhaust valve temperature is caused to rise to a point that may warp the valves. If timing is early, the engine knocks. This action may also cause high temperatures in the cylinders.

2. The Advance and Retarded Spark

a. Proper Spark Advance - The pressure build up should be at the moment the piston is ready to move downward on the power stroke. After the spark occurs in the cylinder it takes .002 to .005 of a second for the fuel mixture to burn and produce a pressure build up. The charge is actually ignited just before the piston reaches top dead center (TDC). The timing by this ignition method is called spark advance. The degree of advance is determined by the following factors: cylinder design, compression ratio, speed of engine, engine load, and fuel characteristics. Most engines are designed with an automatic advance mechanism to give the proper spark advance with different loads and at variable speeds. However, if an engine is not timed properly, it will lack power, run too fast or too slow, overheat, idle rough, knock, misfire, and appear sluggish on increasing the speed.

b. Need of Advance and Retarded Sparks - Advanced spark is needed when the engine is running at high speeds to make certain the air-fuel mixture is fully burning when the piston starts down on the power stroke. Sparking must occur early, because the fuel does not explode on ignition, but rather a burning of the air-fuel mixture throughout the combustion chamber occurs. The varying of the spark occurrence (advance or retard) is regulated by controlling the time of opening of the breaker points. The proper distance to advance the spark is primarily directed by the rate of piston travel. To be efficient, the amount of the spark advance should vary with the engine speed. A retarded spark is needed at certain times. For example, when the engine is first started a retarded spark will prevent the engine from kicking back or even reversing direction of rotation. A retard spark is also needed for low speeds.

Transparency No. 1

3. The Two Methods Used to Time an Engine

   a. Breaker Point Method - The most accurate way to time an engine is to use a timing light, but if a timing light is not available the breaker point method is used. To time an engine by this method (breaker point) the steps are as follows:

      (1) Timing marks may be found either on the fan pulley or engine flywheel. After the marks are located, make them more visible by marking over them with chalk or paint over the marks.

      (2) Loosen the No. 1 cylinder spark plug about two turns and listen for escaped air on the compression stroke as the engine is turned over by hand or by touching the starter lightly. It is a good practice to have the distributor cap removed at this point in order to determine the direction of rotation. Another way to determine when the compression stroke begins is to hold a thumb over the spark plug hole while the engine is being turned. The transmission must be in park or neutral when cranking the engine.

      (3) Refer to the operator's manual to determine the correct timing marks to use, then rotate the crankshaft slowly until the proper timing mark becomes in line with the timing pointer.

      (4) Remove the coil wire from the distributor and hold it about 1/8 inch away from the engine. A spark should jump the gap as the points begin to open. This action is observed with the switch in the "on" position. As the engine continues to rotate and the spark jumps the

gap when the marks are aligned, timing is considered correct. At this point the distributor should be reassembled and the plug replaced.

(5) If the timing mark and pointer are not in line or the points begin to close, then the distributor base clamps must be loosened and the distributor rotated in the direction the rotor turns to retard the spark or time the breaker points open.

(6) With the coil high-tension cable 1/8 inch from the engine (distributor end of cord), turn the distributor in an opposite direction until the spark jumps the gap. Retighten the clamps and reconnect plug wires.

(7) Start the engine and check the firing order. Misfiring or backfiring may be caused from loose or misplaced spark plug wires to distributor. Start with No. 1 cylinder and recheck all wires.

b. Timing Light Method - On most engines the ignition timing can be checked while the engine is operating if the flywheel is marked or there are other timing marks provided. These marks must be located and made visible for use of the timing light. It may be necessary to use a different mark when using a timing light than setting timing by the breaker point method; therefore, reference must be made by using the operator's manual. The procedure used in timing an engine by this method is:

(1) Start the engine and warm it up to an operating temperature. Connect one timing light wire to the No. 1 spark plug and connect the other wire or wires as directed by the timing light manufacturers. The three different types of light connections are:

(a) Two-wire - One wire to the No. 1 plug and one to a ground connection.
(b) Three-wire - One wire to the No. 1 plug and the other two to the battery terminals.
(c) 110-Volt - One wire to the No. 1 plug and a regular power cord connected to a 110 volt circuit.

(2) Set the engine at fast idle and aim the light so that the pointer and centerline on the crankshaft are clearly visible. The timing light will appear in the flicker of light as though it were stationary. If the timing is set properly, the mark and indicator will line up exactly.

(3) Make the following adjustments if the mark or line and indicator do

not line up:

(a) Loosen the bolts holding the clamps on the distributor base.
(b) Move the distributor in the direction to align the timing mark and pointer.

(4) Tighten the distributor clamps in position and remove lead on No. 1 spark plug and other light leads. The idle speed may be rechecked at this point. The firing order is usually stamped on the engine. For example, a six-cylinder engine firing order is usually 1, 5, 3, 6, 2, 4.

On many distributors the direction of rotor travel may be determined by twisting on the rotor. The springs on the advance mechanism will allow turning the rotor about 25 degrees in direction of travel. On some tractors the timing is made in the advanced position. A timing light is recommended for doing this. It is possible to come close by holding the distributor rotor in the advanced position and having the engine set at the advanced timing mark. The distributor is turned against the direction of rotation until a spark occurs.

Usually advanced timing is necessary for good engine operation, because then the full pressure of the burning gases exerts its force on the piston head during the first 90 degrees of crank travel. The idea of advanced timing is to get full pressure of the expanding gases exerted during the first 90 degrees of crank travel. The piston moves down from top dead center a greater distance in the first 90 degrees of crank travel than it moves in the last 90 degrees of crank travel.

4. Timing A Diesel Engine

a. Importance of Timing - Correct timing is very important in a diesel engine. The amount of power of a diesel is more or less based upon fuel being injected at a correct instant. If fuel is injected early or late, the ignition will be delayed, low temperature will result, and there will be a lack of compression. Fuel entering the cylinder late will fire after the piston is past top center. This action reduces the expansion of burned fuel.

b. Injection Pump Timing - A diesel engine is timed by adjusting the fuel or injection pump. Timing of pumps vary from engine to engine; therefore, the manufacturer's manual must be followed. An example of adjusting one type of pump (C. A. V. distributor type diesel injection with automatic advance) is as follows:

(1) With the cover removed from the injection pump body, turn the pump until the marks on the cam plate and drive ring are in line.

(2) Substitute the timing bolt for sealing bolt and tighten. The pump should be locked in a time position. Reinstall the cover.

(3) Use a wire and lead seal to tighten the bolts and seal. Locate the pump on the mounting plate, place drive gear on hub drive, locate properly and tighten bolts.

(4) Turn crankshaft to align timing and degree marks as No. 1 piston nears top dead center (TDC) on the compression stroke. A timing mark should be visible on the back of the camshaft gear.

(5) Install the assembly on the engine. Connect tubing, accelerator linkage, and solenoid.

The aligning of the marks on the diesel engine may be compared to timing of a gasoline engine where timing marks are used.

References:

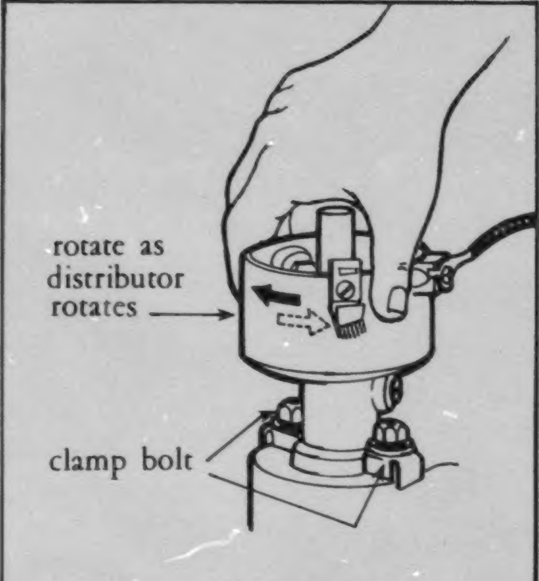
1. Stockel, Martin W., Auto Service and Repair, The Goodheart-Willcox Company, Inc., South Holland, Illinois, 1969

2. Toboldt, William K., Diesel Fundamentals, Service and Repair, The Goodheart-Willcox Company, Inc., South Holland, Illinois, 1973

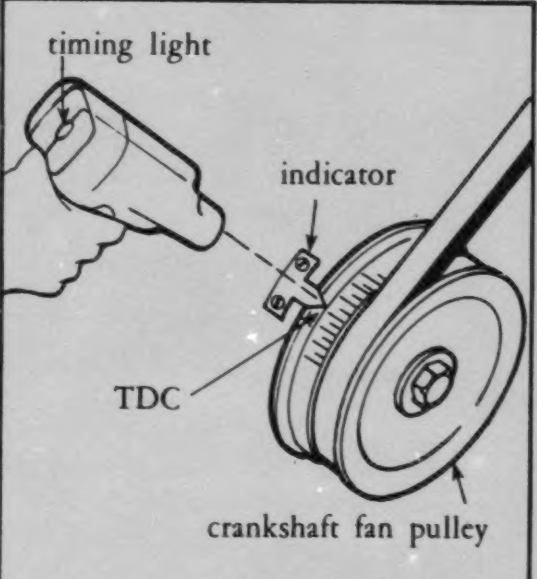
3. "Fundamentals of Machine Operation - Preventive Maintenance", Deere and Company, Moline, Illinois, 1973

4. "Tractor Maintenance - Principles and Procedures", American Association for Vocational Instructional Materials, Athens, Georgia, 1975

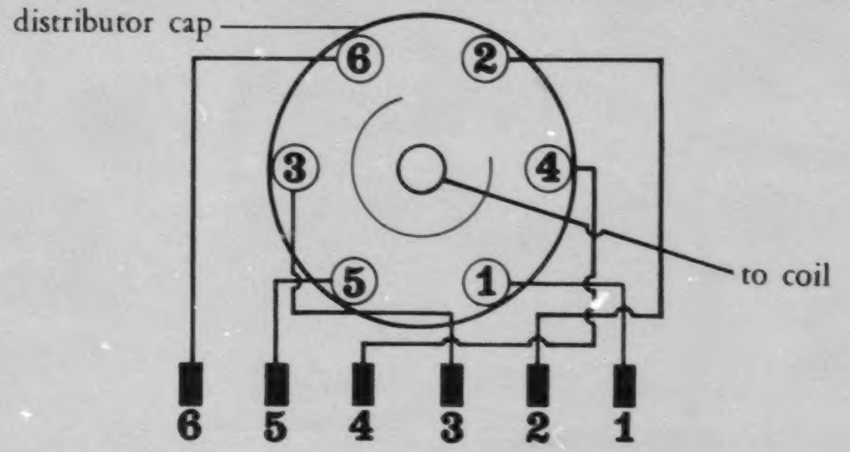
TIMING THE ENGINE


rotate as distributor rotates
clamp bolt

DISTRIBUTOR


timing light
indicator
TDC
crankshaft fan pulley

TIMING WITH LIGHT


distributor cap
6
2
3
4
5
1
to coil
6
5
4
3
2
1

FIRING ORDER - 1,5,3,6,2,4

GENERAL AGRICULTURAL MECHANICS

Unit C: Servicing the Electrical System

Topic 5: Servicing the Generator, Alternator, and Regulator

Suggested Procedures and Activities: The use of either a cut-away or complete alternator and generator and partially disassembled regulator may be helpful during classroom discussion.

Transparencies Nos. 1 and 2

1. Kinds of Charging Circuits and Components

    a. There are two kinds of charging circuits used on farm machines: an A. C. circuit where an alternator is used and D. C. circuit requiring the use of a generator. Actually both A. C. and D. C. circuits generate an A. C. current. The alternator may be considered an A. C. generator.

    The alternating current (A. C.) cannot be used by the battery; therefore, this back and forth type of current is converted into direct current by making it flow in one direction. Diodes (electronic check valves) are used to stop a reverse flow of the current in the alternator.

    The generator rectifies (makes current flow in one direction) its current with commutators and brushes. This system actually develops direct current mechanically. The current is used by the equipment and battery. The alternator also converts mechanical energy into electrical energy that is used by equipment and battery.

    b. The components of charging circuits are:

Charging Circuit (D. C.)	Charging Circuit (A. C.)
Generator	Alternator
Regulator	Regulator
Ammeter	Ignition Switch
Battery	Ammeter
	Battery

2. Operation of A Generator, Alternator, and Regulator

a. The generator and alternator provide current to the ignition system after the engine is in operation. The storage battery provides current to supply the spark to get the engine started. The engine then drives the generator or alternator by a belt that is connected to the driveshaft. The engine usually has to reach a certain speed before a full current load is realized. When the engine is stopped or slowed down, the battery supplies part or all of the electrical load.

Voltage is generated by the generator as the armature rotates between the two magnetic poles. A commutator (ring) is connected to the armature loop, and brushes are connected to wire conductors which are wrapped around the magnets - as the brushes contact the commutator the circuit is complete and the current flows.

The magnetic field rotates in the alternator, and the wire loop is stationary. The magnet is stationary, and the wire rotates in the generator. Rotation of the magnet causes its field to cut across the wire and build up voltage. The magnet lines of force pass from the magnet's north pole and enter its south pole.

The alternator is usually lighter and more compact than the generator. It supplies a higher current at a slower speed, is better adapted to the newer A. C. charging circuits, and supplies current for an idling engine more easily than the generator. Usually less maintenance is required on an alternator than a generator.

Transparency No. 3

b. The electrical wiring system on a tractor is equipped with a cut-out relay regulator. The generator cut-out relay prevents the battery from discharging back through the generator when the engine is not running or when it is idling slowly.

There are three types of regulators found on tractors. They are made up of separate units and a combination of units. Usually, the cut-out relay and the current and voltage regulators are constructed to fit under one cover, but they are separated into three different units due to the three different functions they perform. The voltage regulator limits the heat and voltage produced by the generator. Current output is limited by the current regulator. It is important that the regulators function properly, otherwise high voltage may cause lights to burn out and points to stick or pit and cause damage to the condenser and coil.

A magnetic field is created in the core of the cut-out regulator by the generator building up voltage forcing current through the cut-out winding. The contact points are closed as magnetism pulls the armature to the core. At this point current flows from the generator to the battery.

When the generator stops or slows, the points open, cutting off a reverse flow of current from the battery to the generator. The reversing of the polarity of the series windings causes the opposing fields to reduce the magnetism strength, thus permitting the armature to be released. This action springs the points open.

The voltage and current regulators look about the same. They perform a different function but when one is operating the other ceases to function. The generator output is reduced by resistance being inserted into the generator. This action takes place when the series coil draws the armature toward it, breaking the contact between the points. Reduced output by the generator cuts the magnetism in the coil. The points are drawn back into contact, connecting the generator field to the ground.

The regulator determines the voltage that is put out by the generator. The armature point is drawn away from the stationary contact by the magnetic field. This field is created by the current flow. This action causes the contact circuit to open and resistance input into the generator field circuit. Both current and voltage output are reduced.

Both the cut-out relay and the current regulators are needed when the battery is being charged. Current flows from the generator to the series coil of the current regulator and then to the relay coil. The relay contact points are closed at this point; therefore, the current flows into the battery. As voltage builds up in the battery, the voltage regulator controls the current.

3. The Parts of A Generator and Alternator

a. Generator parts are:

(1) Armature - The armature is made up of many wire conductors that are wound around a soft iron laminated core. The conductors generate voltage.

(2) Commutator - This part is a series of copper bars attached to one end of the armature shaft. The brushes work against the commutator.

(3) Brushes - The brushes are held against the commutator as stated in No. 2 above. They are made of various types of materials.

(4) Pole Shoes - The pole shoes are attached to the inside of the generator frame and the opposing poles for a magnetic field.

(5) Field Circuit - This circuit is wound around the two poles several times, and one end is connected to the brush. They are also fitted against the inside frame and near each end of the armature.

(6) Housing - The components are encased in a metal housing. Air is circulated through the housing by a fan which is located on the pulley end of the generator.

(7) Ball Bearings - Ball bearings are located at each end of the shaft.

(8) End Frames - The commutator frame is located at the rear, and the drive end frame is located at the front of the generator.

b. Alternator parts are:

(1) Rotor - The rotor unit functions as the field coil and pole found in the D. C. generator. It is made up of a wire coil wound around an iron core which is mounted on a shaft.

(2) Stator Assembly - This part functions as the armature found in a generator, but the rotor revolves inside the stator. It is made up of a soft iron ring and three groups of windings.

(3) Rectifier Assembly - This diode assembly is made up of three negative and three positive diodes. The diodes serve as check valves, forcing the A. C. current to flow in one direction, becoming a D. C. current. The stator windings are attached at one end to the diodes. If isolation diodes are used, they are mounted on the end frame.

(4) Brushes - The two brushes rest on the two slip rings. One brush is grounded and the other is connected to the field terminal.

(5) Ball Bearings - These bearings are on each end of the rotor shaft.

(6) Fan - A fan for circulating air through the alternator is mounted on the drive end part. This section is covered with the drive end frame.

c. Main Parts of A Three Regulator Unit

(1) Cut-out relay

(2) Current regulator

(3) Voltage regulator

(4) Terminals
  (a) Battery
  (b) Ground
  (c) Field

Transparencies Nos. 4 and 5

4. Checking and Servicing the Generator, Alternator, and Regulator

a. Before removing parts for repair and getting unit (generator, alternator, or regulator) ready for testing make the following inspection of the unit:

(1) Check generator or alternator belt for the proper tension and damage. At the same time check for loose mountings and pulleys.

(2) Check all connections for proper attachment and corrosion.

(3) Check the wires for burns, grounding, corrosion, and frays.

(4) Check the unit for physical damage before removing it for repair.

(5) Check the storage battery for a full charge before attempting any test.

(6) Check the generator commutator for dirt and grooves.

(7) Check the general output of the generator by using the output test. The general test procedure is as follows: connect a lead from the generator to the battery ground and connect a lead with switch and ammeter from the battery to the generator output terminal. Connect a voltmeter to the generator by connecting one lead to the output terminal and ground the other lead to the generator. Use a jumper lead from the field terminal to the body of the generator (ground). A carbon pile resistor must be connected to each battery pole. This test is for the "A" circuit generator. "B" circuit generators are hooked up differently.

b. Specific tests on the generator, alternator, and regulator require that these electrical units be either partially or completely disassembled.
NOTE: Detailed methods of using testing equipment are explained in Unit B, Topic 3.

(1) Testing the Generator:
  (a) Field Circuit Tests - An open circuit is caused by a broken coil or connection which stops the current flow. A simple test is to touch the prods of a test lamp to the two terminals. The circuit is open if the lamp fails to light.
  (b) Armature Tests - An open armature circuit can be detected by using a test unit and growler. Meter readings are taken on two adjoining commutator bars with the armature rotating. Two other bars are checked with the armature rotating slowly. If one reading is lower than another, the low reading circuit is open.
  (c) Shorted Armature Tests - A metal strip (hacksaw blade) is placed on the armature. The armature is rotated in the growler. If the windings are shorted, the magnetic field will hold and release the metal strip.
  (d) Grounded Circuit - A grounded circuit will also cause the loss of current. The lamp test or test unit can be used to make this check. One prod is placed on the commutator and the other on the armature; if the lamp lights, the armature winding is grounded.

(2) Testing the Alternator:
  (a) Testing Diodes - The test lamp, ohmmeter, and diode tester may be used to test the groups of diodes. If a test lamp is used, one test probe is placed on the base of the diode and the other on the diode lead. If a diode tester is used, tester instructions should be followed.
  (b) Stator Test - If an armature tester or 110 volt test lamp is used, the diodes should be disconnected. Special directions given in the manual should be followed to make the test.
  (c) Rotor Test - The rotor can be tested with an armature tester or voltmeter, 12-volt lamp tester, or a 110-volt lamp tester. If the lamp is used to test for grounds, the end of one probe is connected to the slip ring and the other is connected to the rotor coil. The rotor is grounded if the lamp lights. A voltmeter may be used to check shorted or open winding.

Transparency No. 6

(3) Testing the Regulator:
A regulator unit that is composed of a cut-out relay, current regulator, and a voltage regulator should be tested after bringing the units up to operating temperature. The voltage regulator should be checked first, followed by the cut-out relay, and then the current regulator.

(a) Air Gap Test on Voltage Regulator - The air gap is determined by pressing down the armature until the points touch. The gap is the distance between the armature and regulator core.

(b) Voltage Setting Tests - There are two tests used to check the voltage setting: The fixed resistance and the variable methods test. In the fixed resistance test, one voltmeter lead is attached to the battery terminal and the other to the ground on the regulator, and a 1/4 ohm resistor is inserted into the charging circuit of the battery. A voltmeter and an ammeter are used in making the variable resistance test. One voltmeter lead is attached to the regulator battery terminal and the other to the ground. The ammeter leads are connected to the battery terminal on the regulator and to a variable resistor. The variable resistor is also connected to the battery charging circuit. The generator is cycled when making a fixed or variable test.

(c) Current Tests - The air gap is checked in the same manner as making the voltage air gap test. The ammeter and voltmeter are connected to the same terminals that are used to make the variable resistance voltage test. A variable resistor is used on the field lead when using the ammeter and voltmeter.

c. When servicing a generator, alternator, or regulator it is very important that the technical manual instructions be followed.

(1) Servicing the D. C. Generator - Disassemble all parts of the generator except the pole shoe and field coil. It may be necessary to remove the drive pulley with a wheeler puller. All parts should be cleaned in a solvent except the armature, brushes, and field coils.

Check the commutator for oxidation and dirt. If it is out-of-round it should be turned in a lathing tool. A dirty commutator can be polished with No. 00 sandpaper. It is not advisable to use emery cloth. After turning or sanding a commutator, use air to remove foreign particles (dirt, metal, etc.).

Use a hacksaw blade or undercutting machine to cut the mica insulation about 1/32 inch below the rib surface.

Check the end bearings and end plate bushings for wear or scoring. Replace these parts if wear is present.

Replace the brushes if the generator is disassembled. Normally brushes are replaced if they are worn to one-half the original length. At least 25 percent of the brush area should contact the commutator. The contact area should be near the center of the brush. Check the brush tension against manual recommendations. Brushes can be seated by taping a piece of sandpaper around the commutator and turning the armature. This seating method is accomplished after the generator is assembled.

Polarize the generator after it is installed and before cranking the engine. If the current flows in the reverse direction, it will burn out the cut-out relay points. An "A" circuit generator is polarized by connecting a jumper wire to the regulator battery terminal and scratching the other end on the generator terminal. This one-second operation will cause current to flow in the proper direction. A "B" circuit generator is polarized by removing both the battery and field wires from the regulator terminals and touching them together. These wires should not be applied to the terminals. After the loose wires are scratched together, they are replaced on the terminals.

To be sure that all parts are functioning properly, start the engine and check the generator.

(2) Servicing the Alternator - It may be necessary to use a puller to remove the drive pulley, plates, and bearings when disassembling an alternator. The slip ring end frame and drive end frame can usually be pried apart.

Remove the starter leads from the screw terminal and remove the diode assembly on the closed-type alternator. If the alternator is an open-type the diode leads are removed by unsoldering each lead.

If individual diodes must be replaced, the used diode must be pressed out and a new one pressed in, if the alternator is the open-type. The entire diode plate assembly (positive and negative) is replaced on some alternators.

Usually it is not necessary to remove the bearings from the shaft unless they need replacing.

Replace the brush assembly if the brush is shorter than about 1/4 inch. If the alternator is being overhauled it is advisable to replace the brushes regardless of their condition.

Turn the slip rings if they are scored or out-of-round, but remove as little metal as possible. If the slip rings are dirty, 400 grain polish cloth may be used to remove the dirt.

Check the rotor bearings for wear and scoring. A worn bearing should be replaced. Alternators, unlike D. C. generators, are not polarized.

(3) Servicing the Regulator - The alternator regulator is different from a D. C. generator regulator in that it does not have a cut-out relay or a current regulator. Many alternators have only a voltage regulator. Some alternators do have a field relay and an indicator light relay. Actually, the current regulates itself and diode rectifiers permit current to flow from the alternator to the battery, but it eliminates the reverse flow from battery to alternator.

Clean the regulator points with No. 400 silicon paper or similar abrasive, if the points are soft. If one point is soft and the other is hard, use the proper file on the hard point. If a concave point is oxidized, use a riffler file to clean the point. Points can be wiped with alcohol after filing.

Check the cut-out relay air gap by forcing the points closed with the pressure of the thumb. The pressure is applied directly over the points. Measure the gap by using a gauge placed between the armature and core center. Adjustment is made by loosening the adjusting screws and moving the armature until the proper gap is obtained. The cut-out relay point opening is set by moving the adjusting screw and taking measurement with the gauge.

Make adjustments on the current and voltage regulators by adjusting the spring tension on the regulator. This adjustment is accomplished by turning a screw. It is necessary to use a tester or voltmeter and ammeter for making correct adjustments.

Readings for making regulator adjustments are given in the technical manual. It is very important that technical manual instructions be followed when setting the current, voltage, and cut-out relays on the many different types of regulators.

References:

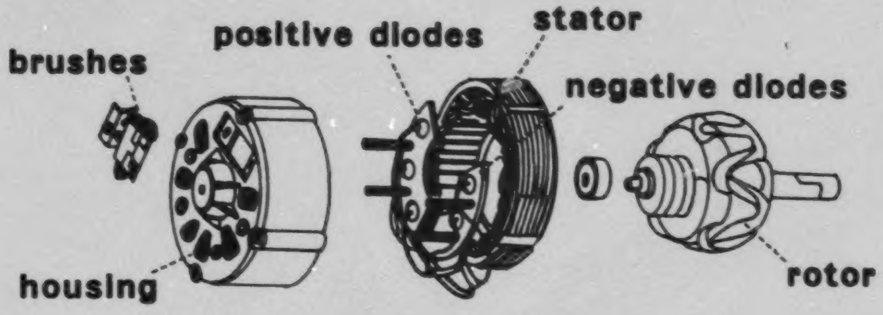
1. Stockel, Martin W., Auto Service and Repair, The Goodheart-Willcox Company, South Holland, Illinois, 1969

2. "Fundamentals of Service - Electrical Systems", Deere and Company, Moline, Illinois, 1972

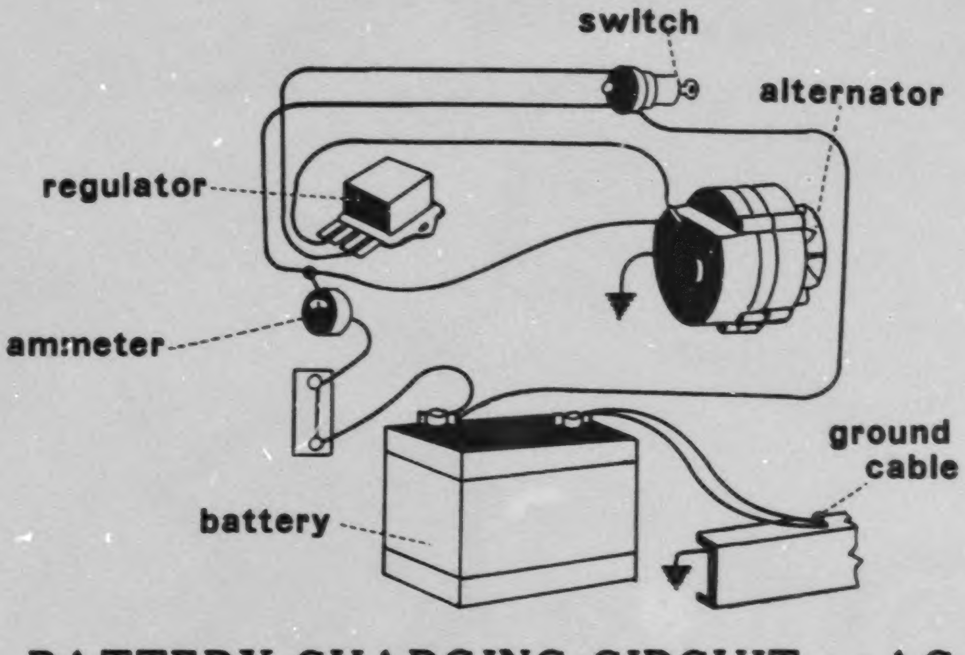
3. "Fundamentals of Machine Operation - Preventive Maintenance", Deere and Company, Moline, Illinois, 1973

4. "Tractor Maintenance - Principles and Procedures", American Association for Vocational Instructional Materials, Athens, Georgia, 1975

ELECTRICAL SYSTEM


brushes
positive diodes
stator
negative diodes
housing
rotor

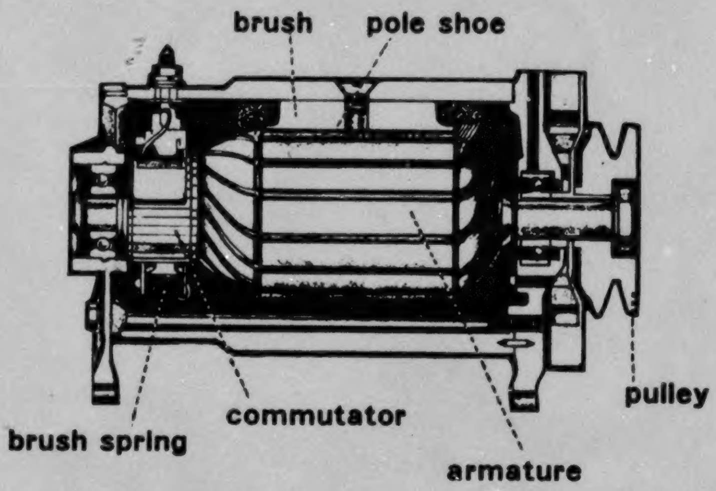
ALTERNATOR

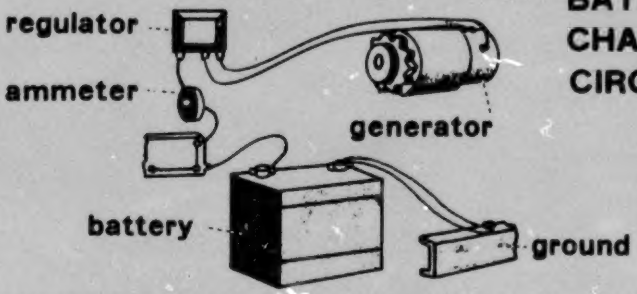

switch
alternator
regulator
ammeter
ground cable
battery

BATTERY CHARGING CIRCUIT — AC

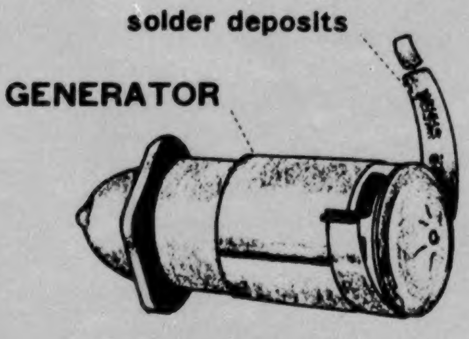
ELECTRICAL SYSTEM

DC GENERATOR

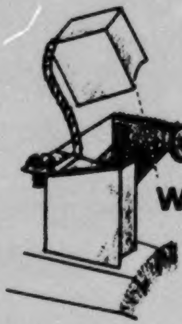

brush
pole shoe
pulley
commutator
brush spring
armature


regulator
ammeter
generator
battery
ground

BATTERY CHARGING CIRCUIT - DC

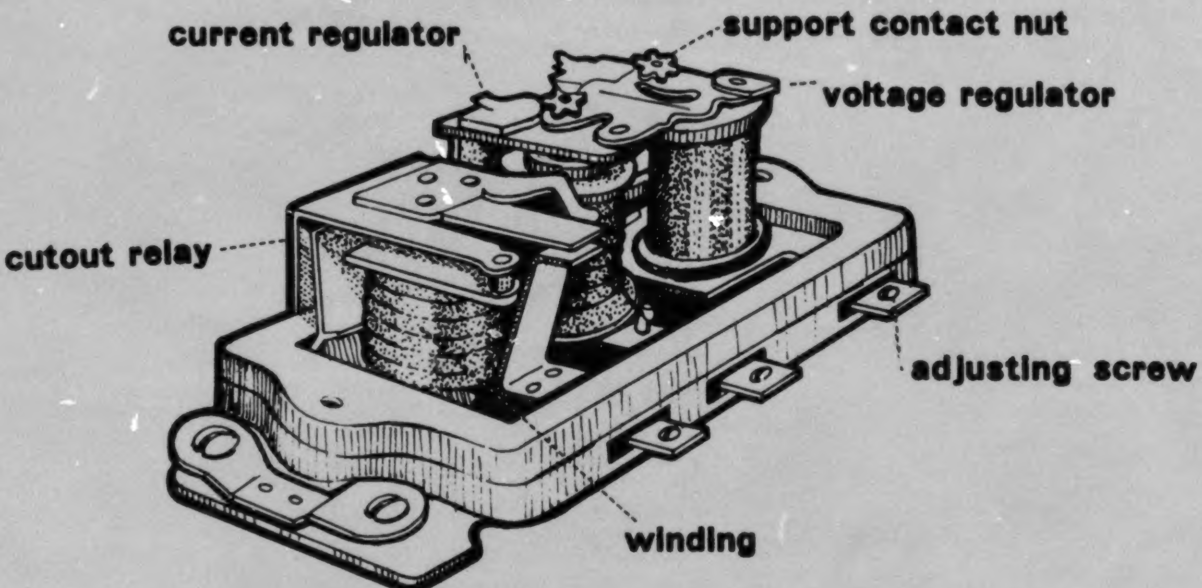

solder deposits

GENERATOR

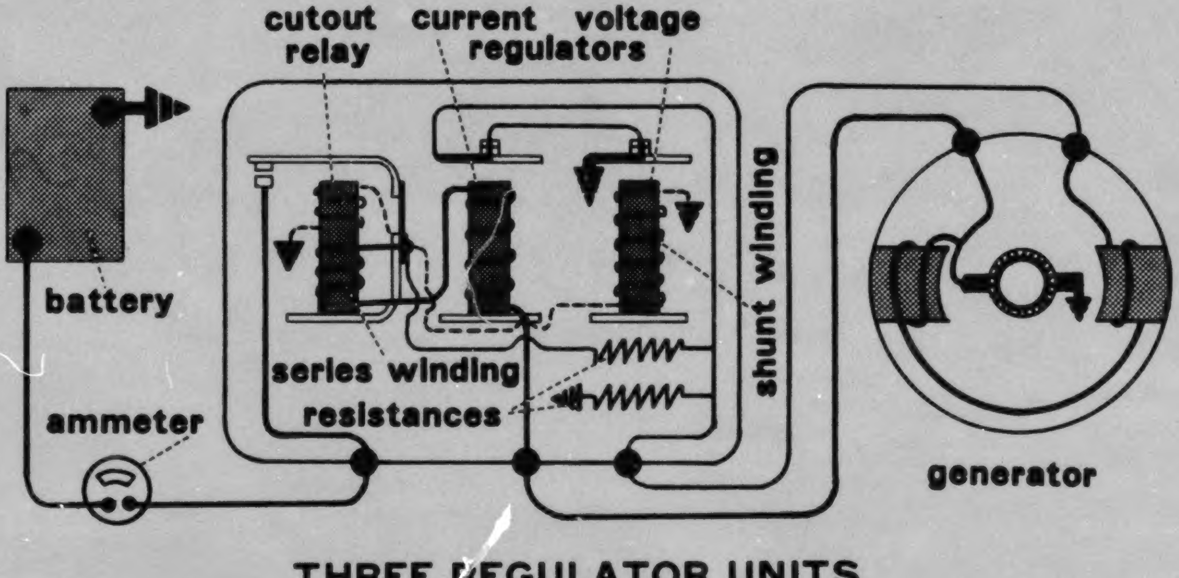


WORN BRUSH

ELECTRICAL SYSTEM

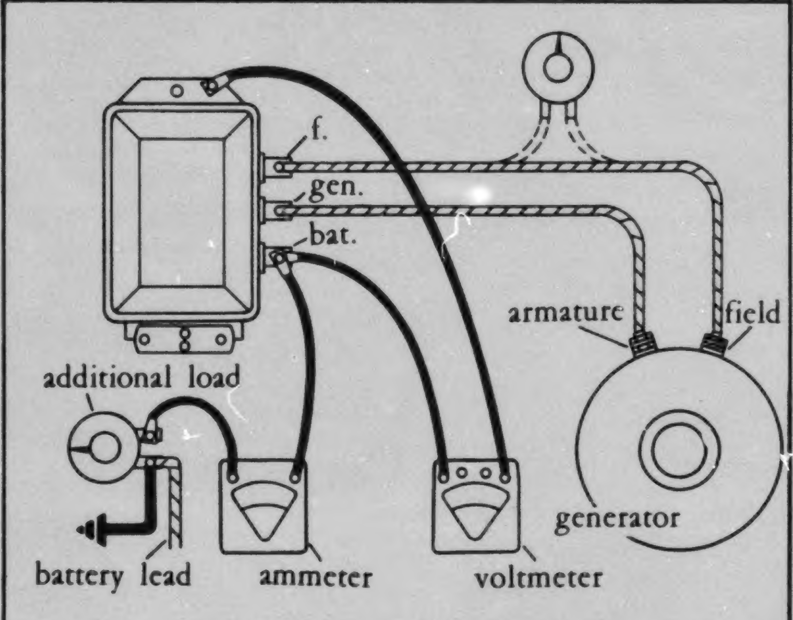

current regulator
support contact nut
voltage regulator
cutout relay
adjusting screw
winding

REGULATOR UNITS

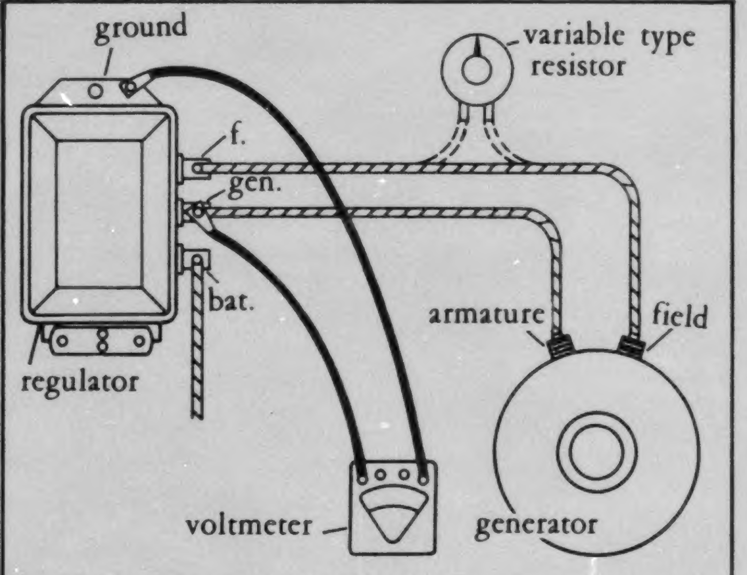

cutout relay
current
voltage
regulators
battery
shunt winding
series winding
resistances
ammeter
generator

THREE REGULATOR UNITS

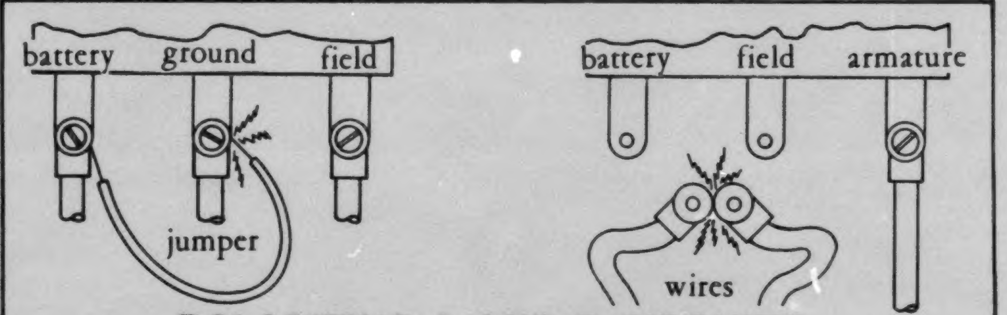
ELECTRICAL SYSTEM TESTS


f.
gen.
bat.
armature
field
additional load
generator
battery lead
ammeter
voltmeter

CURRENT SETTING TEST

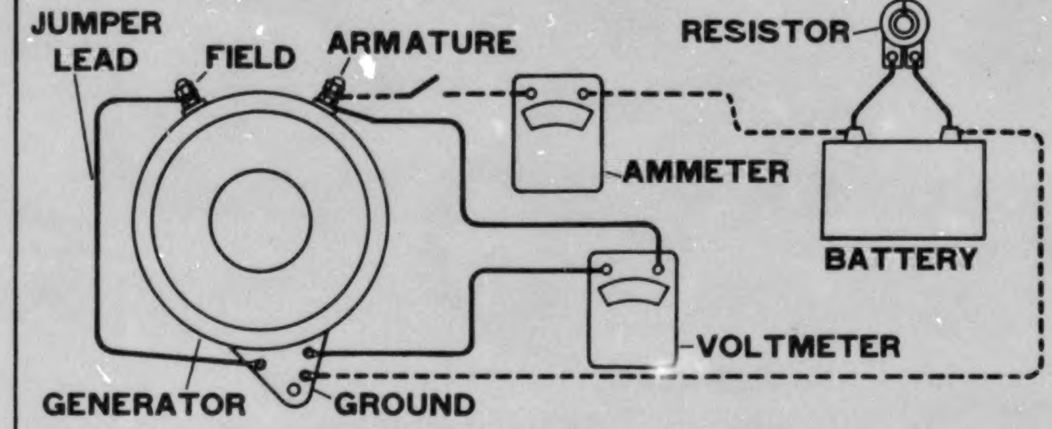

ground
variable type
resistor
f.
gen.
bat.
armature
field
regulator
voltmeter
generator

CLOSING VOLTAGE TEST OF CUTOUT RELAY

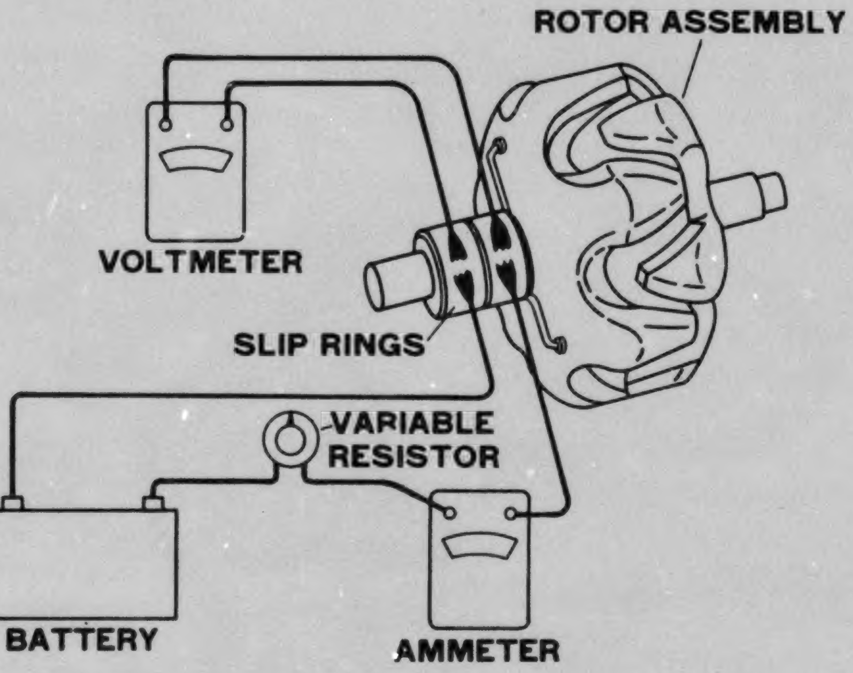

battery
ground
field
jumper
battery
field
armature
wires

POLARIZING A AND B CIRCUITS

ELECTRICAL SYSTEM TESTS


JUMPER LEAD
FIELD
ARMATURE
RESISTOR
AMMETER
BATTERY
VOLTMETER
GENERATOR
GROUND

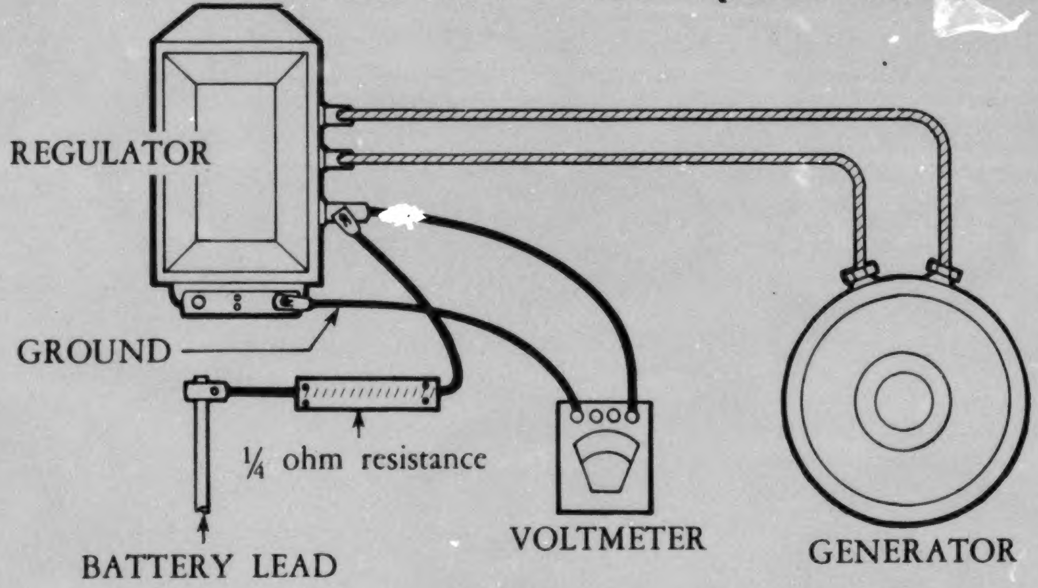
OUTPUT TEST - "A" CIRCUIT


ROTOR ASSEMBLY
VOLTMETER
SLIP RINGS
VARIABLE RESISTOR
BATTERY
AMMETER

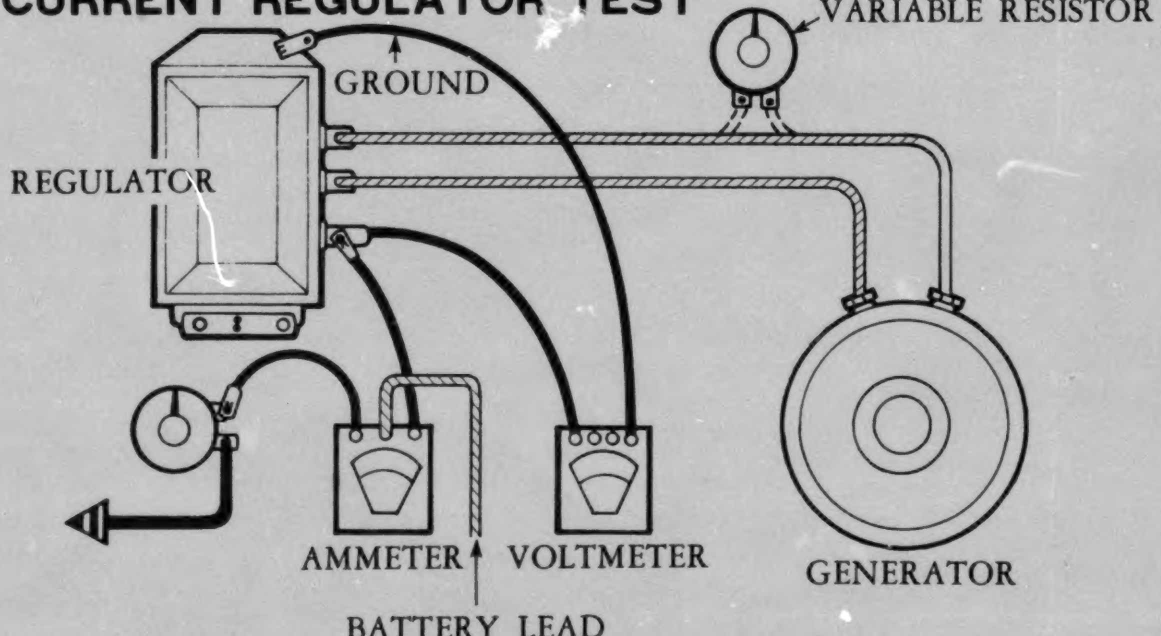
ROTOR ASSEMBLY TEST

ELECTRICAL SYSTEM TESTS

VOLTAGE TEST (fixed resistance)


REGULATOR
GROUND
¼ ohm resistance
BATTERY LEAD
VOLTMETER
GENERATOR

CURRENT REGULATOR TEST


VARIABLE RESISTOR
GROUND
REGULATOR
AMMETER
VOLTMETER
BATTERY LEAD
GENERATOR

GENERAL AGRICULTURAL MECHANICS

Unit C: Servicing the Electrical System

Topic 6: Servicing Starter Motors

Suggested Procedures and Activities: The use of a disassembled starter as a teaching aid may be helpful during the classroom discussion.

Transparency No. 1

1. The Starting System

The starting system is also known as the cranking system and the starting motor is called the cranking motor.

A starting motor is of either the six or twelve volts direct current type. This motor makes up only part of the starting system. Other components are: the battery, switches, wires, and solenoid. The motor consists of the following major parts: armature, commutator, field coil, brushes, overrunning clutch, shift lever, motor switch, drive gear, and housing. Electrical energy furnished by the battery is converted into mechanical energy at the starter to start the engine. Starting motors may have two, four, or six field poles and two, four, or six brushes.

Transparencies Nos. 2 and 3

2. Functions of A Starting Motor and Its Parts

   a. The starting motor is attached near the engine flywheel. When the starter switch is closed, electric energy flows through the heavy wire from the battery to the solenoid. The battery current causes a movement of the solenoid plunger. The plunger, in turn, moves the solenoid shift lever that forces the pinion to engage the flywheel. As soon as the flywheel begins to turn faster than the starting motor, the pinion automatically disengages from the flywheel.

   b. The functions of starting motor parts are as follows:

      (1) A magnetic field is developed between two poles pieces (ends of magnet).

(2) The strength of the field is increased by passing current through a wire (field winding) that is wound around the pole pieces.

(3) The main part of the motor is the armature. It is made up of wire windings or loops that are attached to metal parts which make up the commutator. Electricity (current) flows from the battery and passes through sliding brushes to the commutator.

(4) The armature operates between the poles. A magnetic field is formed around the loops. This field opposes the magnetic field between the two poles causing the armature to turn.

Transparencies Nos. 2 and 3

3. The Different Types of Switches for Starting Motors

The types of motor starting switches are:

a. Manual - The manual switch is operated by hand to open or close an electrical circuit. It is usually mounted on the frame of a machine or the frame of the starting motor. It may be operated by a hand lever or other device.

b. Magnetic - Magnetic switches are mounted on the housing of the starter motor. The principle of the magnetic switch operation is as follows:

The magnetic field can be strengthened by placing a soft metal core in the coil. The polarity of a coil switch is the same as the core. Adjacent poles are opposite in polarity until the core is drawn into the coil by the flow of current. When the circuit is closed, the core contacts the terminal by a disk as the plunger overcomes spring tension, completing the circuit and starting the engine. The circuit is controlled at the starter switch.

c. Solenoid - A solenoid switch operates similarly to a magnetic switch. It has a heavy wire winding (pull-in) and a fine wire winding (hold-in). Current flows to the solenoid from the battery when the starter switch is turned on. A strong magnetic field is created by the current flowing in the two coils in the same direction. This strong current pulls in the plunger, which pushes out the shift lever, engaging the drive pinion. Only the hold-in winding is energized during cranking.

d. Series - Parallel switches of this type are used to start heavy duty engines. They are used on some diesel engines. Two 12-volt batteries mounted parallel to each other are used to give adequate starting power. A solenoid coil creates a magnetic force that operates a plunger which closes two terminals and connects the two batteries. The battery to starting motor circuit is completed, and the motor turns over.

4. Types of Starting Motor Drives

a. The Bendix drive has been one of the most commonly used drives on starter motors for many types of machines. The armature is put into motion very rapidly, causing the pinion gear to move forward on the turning screw sleeve until it meshes with the flywheel gear. At the time the engine starts, the pinion spins out of mesh. The Bendix drive remains out of mesh while the engine is running.

b. The overrunning clutch drive is one of the most commonly used starting motor drives on modern engines. It is equipped with a shift lever that moves the clutch and pinion on the armature shaft until the pinion gear meshes with the flywheel. The pinion gear is unlocked from the armature shaft and separates from the flywheel as the engine starts.

5. Servicing the Starting Motor

There are numerous tests that may be made on the starting circuit. Most tests and checks can be made without removing parts of the circuit.

a. Some major problems found in the starting circuit are:

(1) Cranking speed uneven or slow. The cause of this problem may be shorted or grounded winding, uneven compression, high resistant connections, or damaged pinion and/or flywheel gears.

(2) The starting switch is turned to the on position and there is no audible click from the solenoid or sound from the starting motor. This indicates that the problem is either in the switch, wire leading to the solenoid, or in the solenoid.

(3) The starting motor turns at a normal speed but fails to turn the engine. It may be necessary to disassemble the starter to determine if the armature is broken, if the drive assembly is dirty, if assist springs are weak, or if there is a damaged overrunning clutch.

(4) The solenoid clicks when the switch is closed, but the starting motor fails to run. This condition may indicate that the starting motor is damaged or the circuit is open in the hold-in winding of an overrunning type drive. Also, the problem may be caused by a damaged commutator, sticking or worn brushes, or damaged bearings.

(5) The starting motor drive fails to disengage from the flywheel. This problem may be caused by the solenoid pull-in windings, solenoid circuits, or solenoid contacts. The problem may also be in the drive part of the starting motor.

Transparencies Nos. 4 and 5

b. Some common checks and tests used on starting motors are:

(1) Visual tests are made by examining the circuit wiring, terminals, or connections, and any other source that may cause high resistance. This test will involve checking for corrosion at the battery terminals, burned commutator bars, loose bolts, oily and worn brushes, armature drag or worn bearings, and freedom of movement of the armature and drive assembly.

(2) Cranking voltage test may be made by using a voltmeter or volt-ignition tester. This test should be made according to the primary circuit on the machine. Prevent the engine from starting by connecting a jumper lead from the primary terminal of the distributor to ground. Turn the ignition switch to on position and crank the engine. Observe voltmeter readings at the following points: voltmeter leads connected to ground and positive battery terminal if there is no by-pass circuit. Where there is a by-pass circuit in the switch (by-passing a ballast resistor) the voltmeter leads are attached to the battery wire from the switch that is connected to the coil. If the by-pass is in the solenoid the same voltmeter lead connections are used. A reading of 10 volts is considered adequate. A reading of less than nine volts may indicate a weak battery, corroded cables, poor connections, or defective switches and by-pass circuits.

(3) A no-load test is used to determine the internal conditions of a starting motor. The test is performed in the following manner. Connect an ammeter and resistor between the starting motor and a fully charged battery. Use a jumper lead on the solenoid "S'

and battery terminals. Attach the voltmeter leads to the starting motor terminal and to the frame of the machine. Use a tachometer on the end of the armature to check its speed. Adjust the variable resistor until the desired reading is observed on the voltmeter, then read the ammeter for current drawn and the tachometer for armature speed. The readings are compared to the starting motor specifications.

A low speed and high current reading may indicate a grounded armature, damaged motor parts, or a shorted armature. A low speed and low current may mean defective leads and connections. If there is a high current draw and the motor will not run, either the bearings are frozen or there is a direct ground in the terminal. The motor will not operate if there is an open field circuit, badly worn or broken brushes, open armature coils, or burned bars on the commutator.

6. Starting Motor Disassembly

If the starter motor does not meet specifications as indicated by the no-load and other tests, it may be necessary to disassemble the unit to repair and replace parts.

The steps in disassembling a starter are:

a. Remove the end plate at the commutator. Use chalk or other marking material to identify parts for reassembly.

b. Remove the brushes with care. Brushes are located either on the end frame or in the main frame. Check the brushes to determine their sliding position on the commutator. If the brushes measure one-half or less their original length, they should be replaced.

c. If the solenoid is mounted externally, it can be removed with the main frame.

d. Remove the main frame and check the commutator. It may show evidence of arcing, excessive wear, or be discolored.

e. Disconnect the solenoid shift lever from the drive housing; then remove armature from the drive housing. The housing should be inspected for cracks and the bearings for wear. Inspect the armature shaft for signs of overheating, and the overrunning drive to determine whether or not it slides easily on the splines. The pinion should be checked at this point for excessive wear or damage. The Bendix drive pinion gear should be checked for wear and damage, and the spring should be checked for distortion.

Transparency No. 6

7. Reconditioning or Replacing Starter Motor Parts

a. After the starter motor has been disassembled, additional tests are made to determine the need for reconditioning starter parts. Those tests are:

(1) Test the armature shaft for straightness. This can be accomplished by placing the shaft in V-block or on a lathe and setting a dial indicator so that it will register the straightness as the shaft is rotated.

(2) Test the armature for short circuits by placing it in a growler and holding a straight thin piece of metal (hacksaw blade) on the armature while it is being turned on the growler. The piece of metal will vibrate at the point of a shorted section in the armature.

(3) Test for a ground in the armature is made with a test light. One prod is placed on the commutator segments and the other on the armature. A grounded armature will cause the lamps to light.

(4) Test field coils for grounds by placing one prod on the field coil connector and the other prod on the starter frame or ground. A lighted lamp indicates a ground. The connectors, brushes, open wires, or any part of the field circuit must not touch the frame. A shunt coil must be disconnected before making this test.

(5) Test the field coil for an open or broken circuit by placing one lamp prod on the solenoid connector and the other on the insulated brush lead. This is the same test as placing the lamp prods on each end of the coils. If the lamp fails to light, the circuit is open or broken.

(6) Test the insulated brush holders for ground with a test lamp. One prod is placed on the brush holder and the other on the frame. The test lamp should not light if there is no ground.

b. Reconditioning steps are as follows:

(1) Remove the brush and copper dust that collects between the commutator bars. It may be necessary to undercut the mica (insulation between commutator bars) about 1/32 inch.

(2) Always replace the brushes if the starter is disassembled for any purpose. Brushes that are worn, out of shape, or oil soaked must be replaced. Adjust spring tension for proper contact. Use matched sets when adding new brushes.

(3) Sand the commutator with No. 00 sandpaper. Emery cloth should not be used.

(4) Replace field coils to eliminate any possibility of shorting or grounding. If the pole shoes have a long tip, they are installed with the long tip in the direction of armature rotation.

(5) Replace worn or damaged commutator and frame bushings. The oil wick hole must be cleaned and a new wick supplied. The bushings must be the proper size for the armature shaft.

(6) Replace the pinion if the gear teeth are severely worn and broken. The pinion must make proper contact with the flywheel.

(7) Recheck all solder connections and repair those that are improperly connected. Also, check the shift lever on an overrunning starter. A badly worn lever should be replaced.

(8) Use a feeler gauge to check the pinion clearance after the starter is assembled. The starter technical manual should be used to determine the proper clearance. Different starter motors have different clearances.

(9) Replace distorted springs on a Bendix type starter.

c. The servicing of a starter motor is not complete until all parts have been cleaned and installed properly. Most parts can be cleaned in a solvent. The armature, field coils, commutator, and overrunning clutch should not be cleaned in a solvent. These parts may be wiped with a clean solvent rag, but they must not be washed in a cleaning fluid. The Bendix drive can be washed in a solvent.

References:

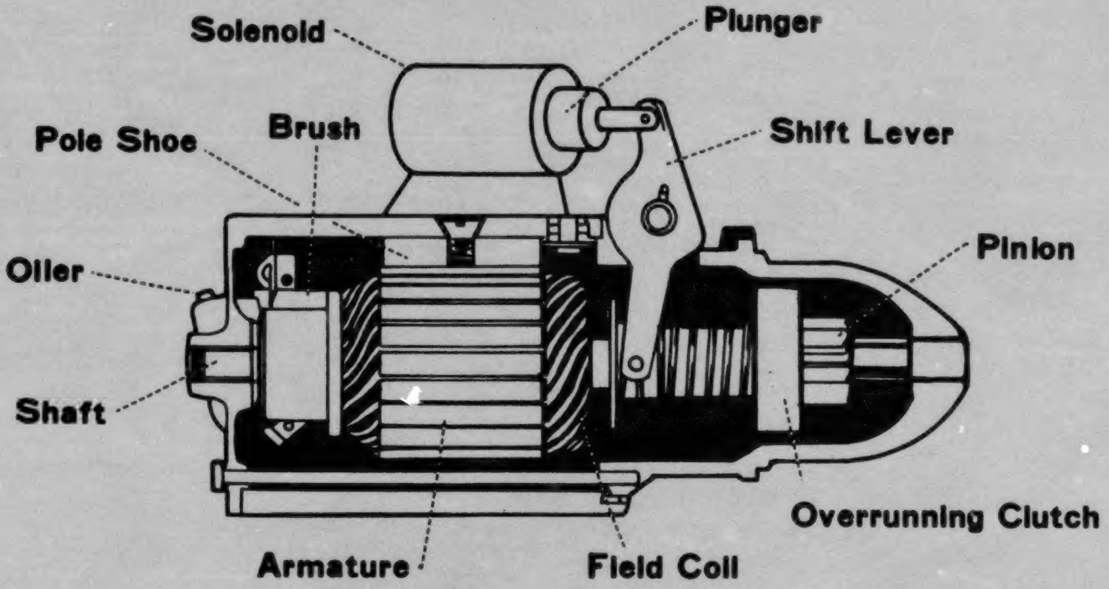
1. Promersberger, William A., and others, Modern Farm Power, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1971

2. Stockel, Martin W., Auto Service Repair, The Goodheart-Willcox Company, Inc., South Holland, Illinois, 1969

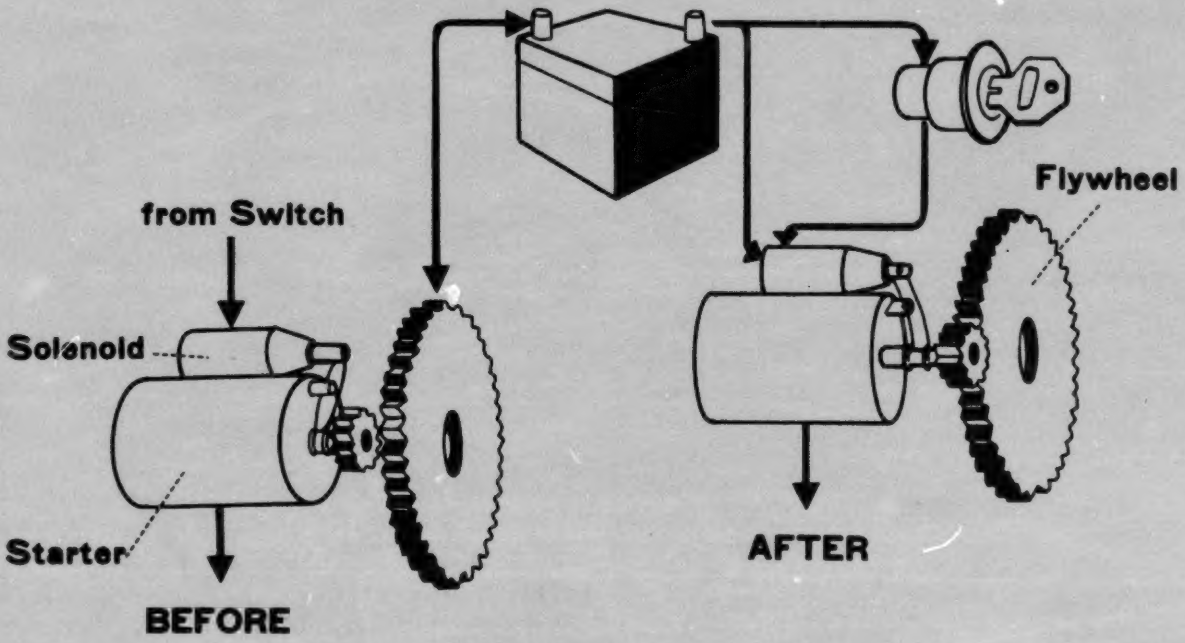
3. "Fundamentals of Service - Electrical Systems", Deere and Company, Moline, Illinois, 1972

4. "Fundamentals of Machine Operation - Preventive Maintenance", Deere and Company, Moline, Illinois, 1973

STARTERS

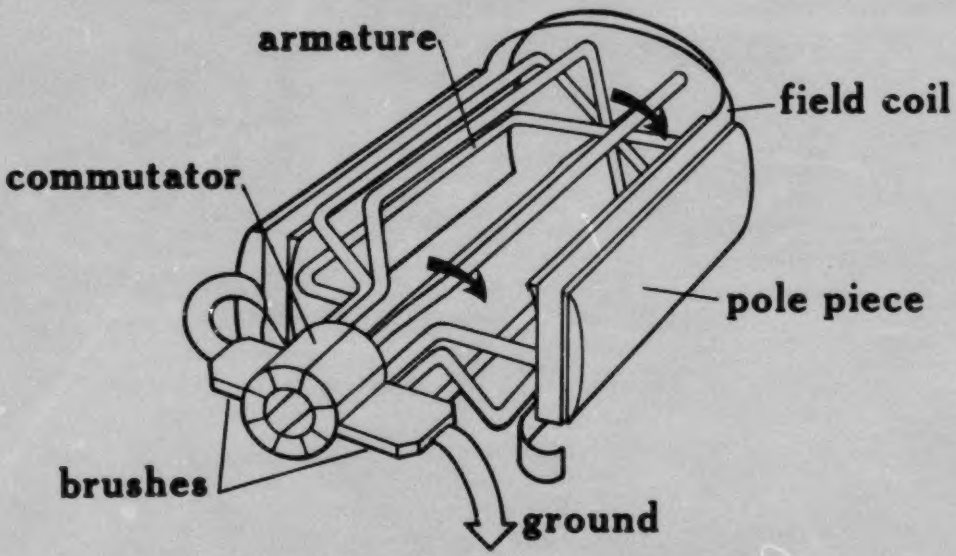

Solenoid
Plunger
Pole Shoe
Brush
Shift Lever
Oiler
Pinion
Shaft
Overrunning Clutch
Armature
Field Coil

STARTING MOTOR

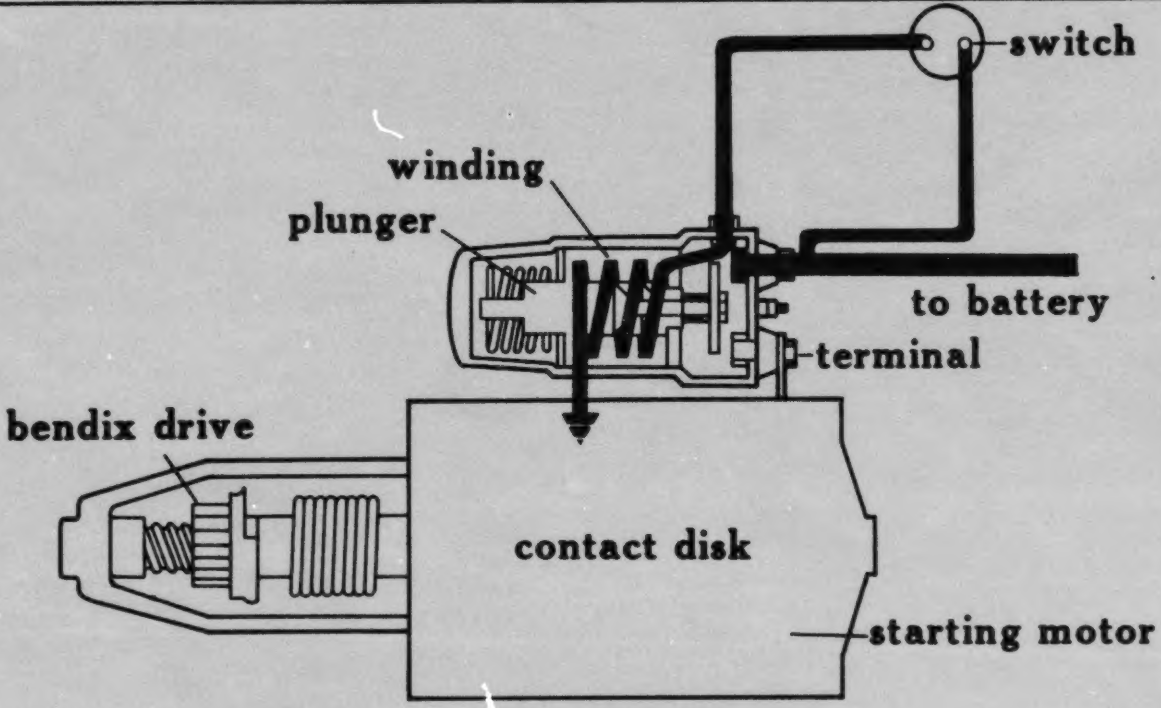

Flywheel
from Switch
Solenoid
Starter
BEFORE
AFTER

PINION ENGAGES FLYWHEEL

STARTERS

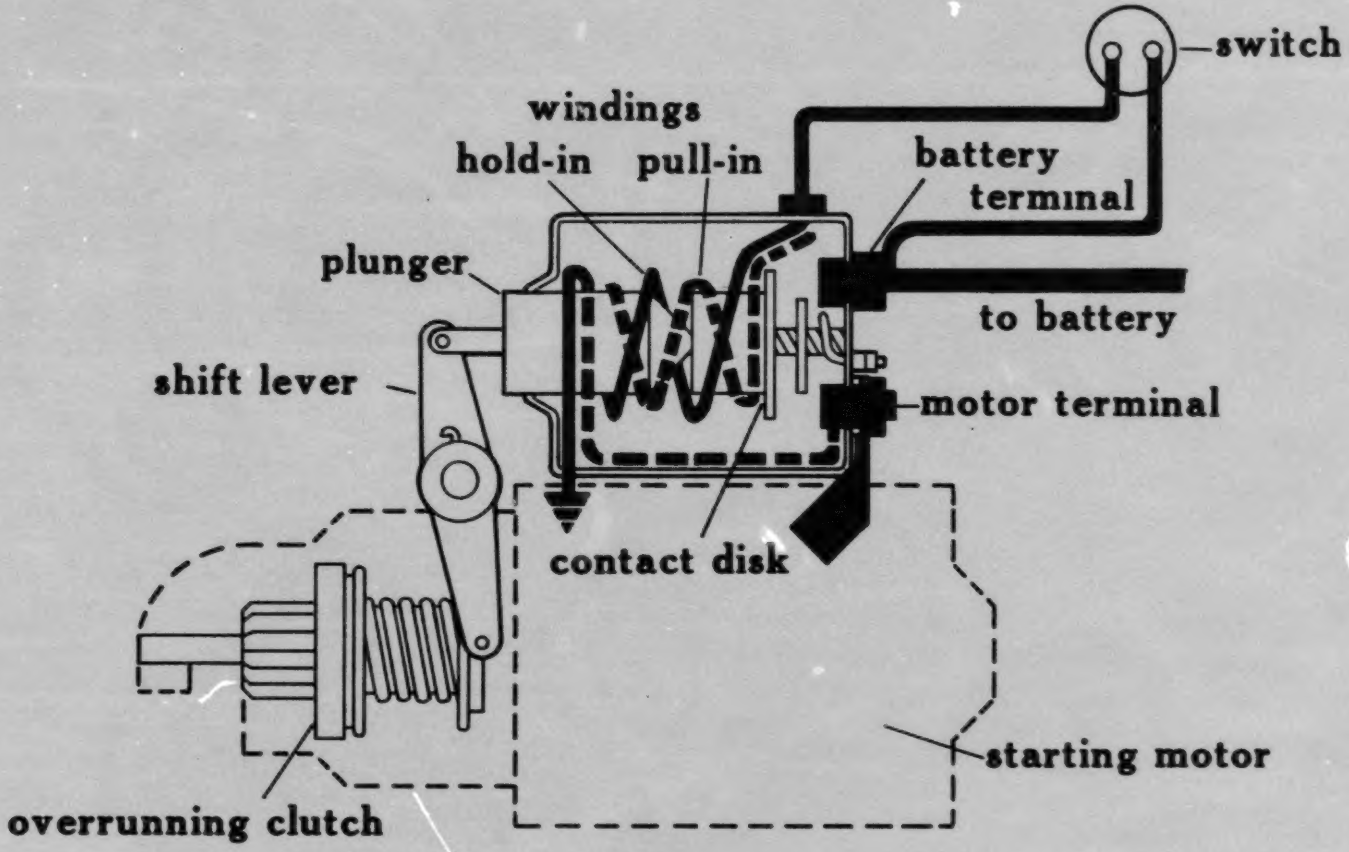

armature
field coil
commutator
pole piece
brushes
ground

STARTING MOTOR ARMATURE


switch
winding
plunger
to battery
terminal
bendix drive
contact disk
starting motor

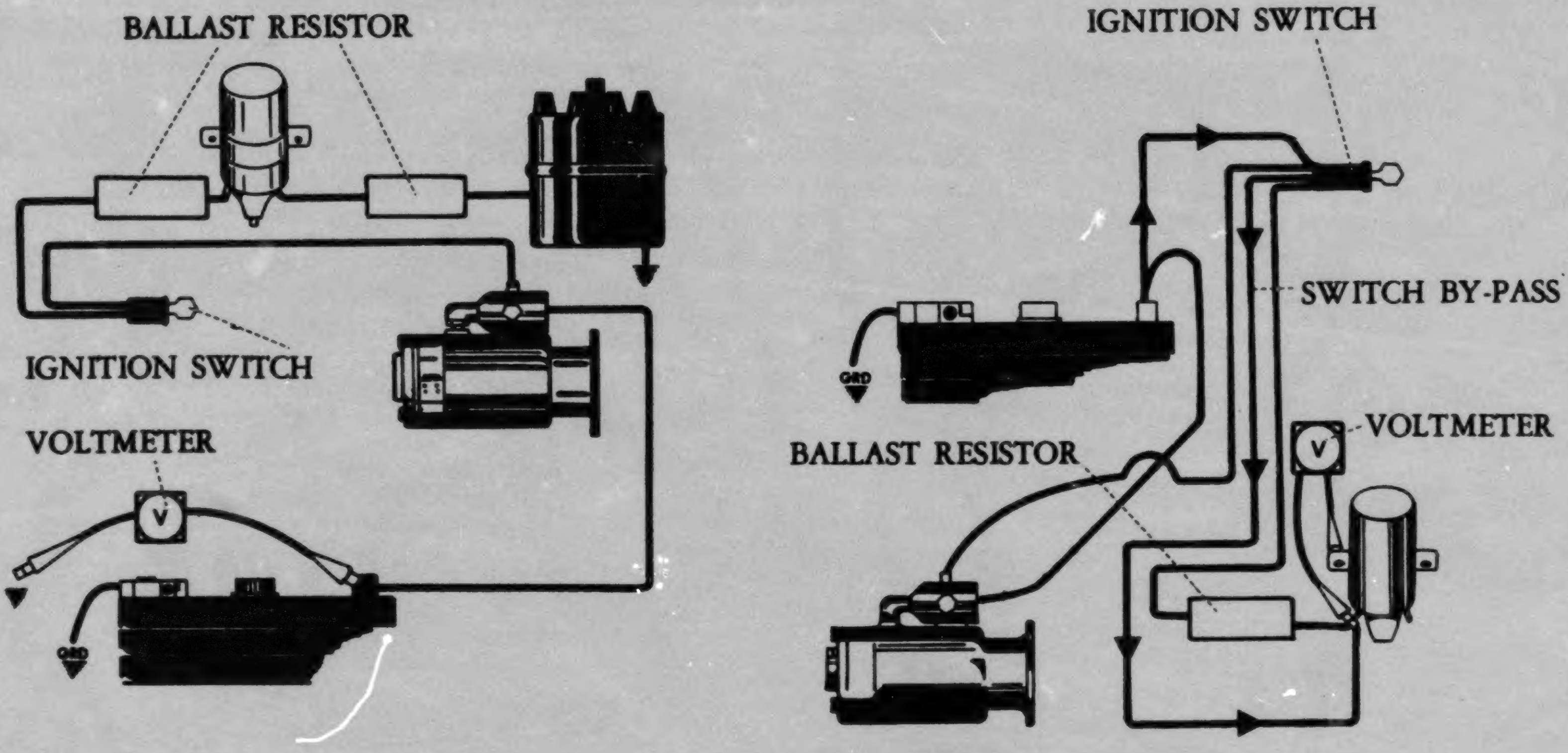
MAGNETIC SWITCH CIRCUIT

STARTERS


switch
windings
hold-in
pull-in
battery terminal
plunger
to battery
shift lever
motor terminal
contact disk
starting motor
overrunning clutch

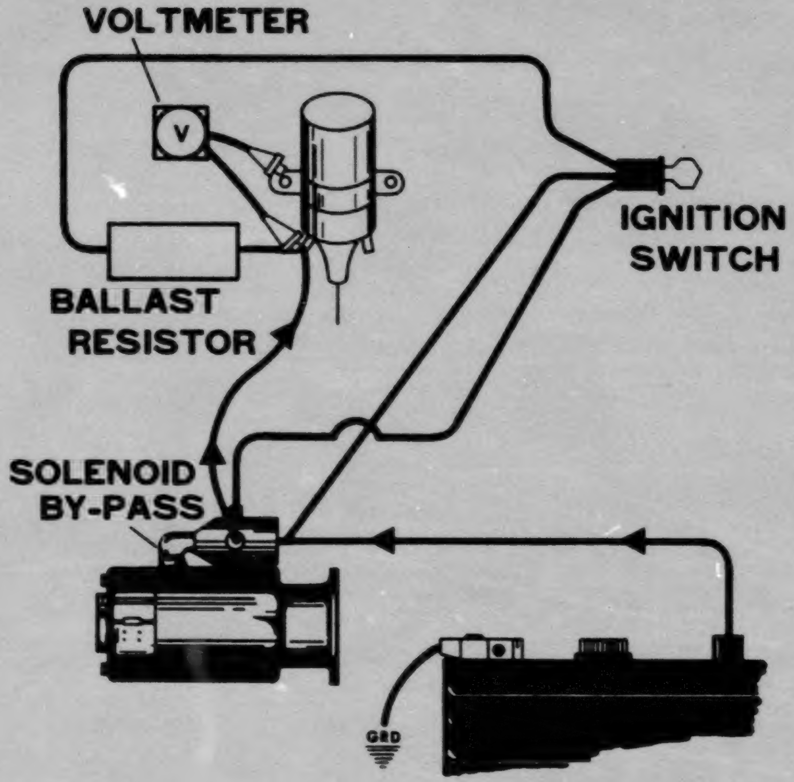
SOLENOID CIRCUIT

STARTERS

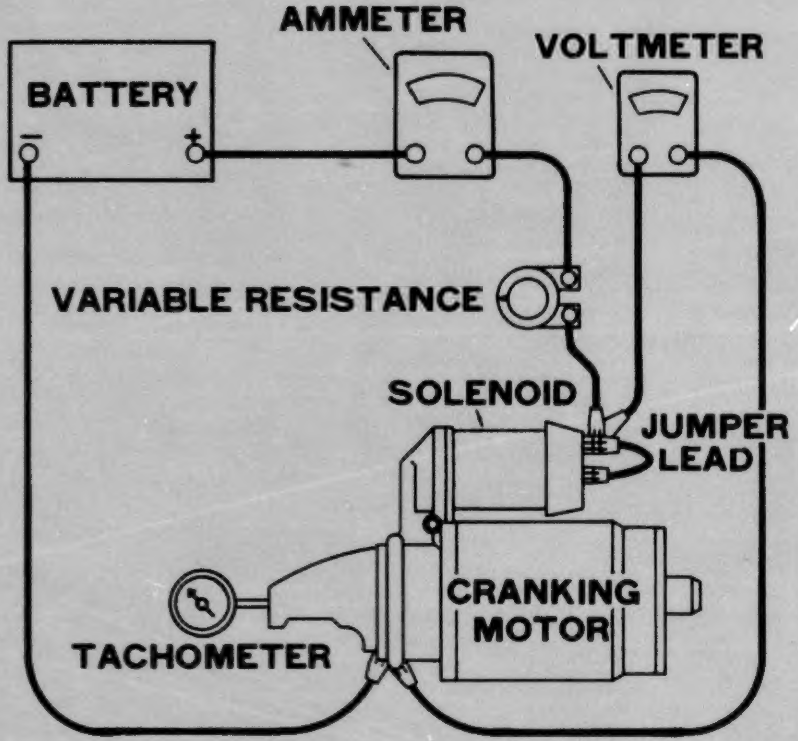

BALLAST RESISTOR
IGNITION SWITCH
VOLTMETER
V
GRD
IGNITION SWITCH
SWITCH BY-PASS
GRD
BALLAST RESISTOR
VOLTMETER
V

CRANKING VOLTAGE TEST

STARTERS

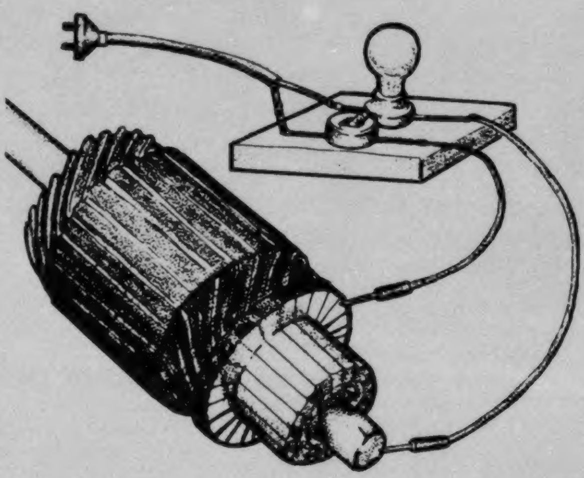

VOLTMETER
V
IGNITION SWITCH
BALLAST RESISTOR
SOLENOID BY-PASS
GRD

CRANKING VOLTAGE TEST

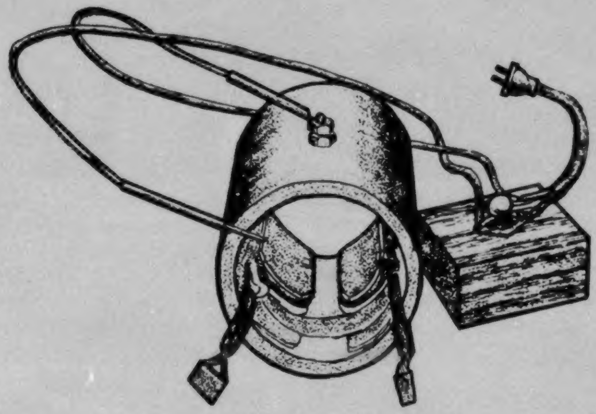

AMMETER
VOLTMETER
BATTERY
−
+
VARIABLE RESISTANCE
SOLENOID
JUMPER LEAD
CRANKING MOTOR
TACHOMETER

NO-LOAD TEST

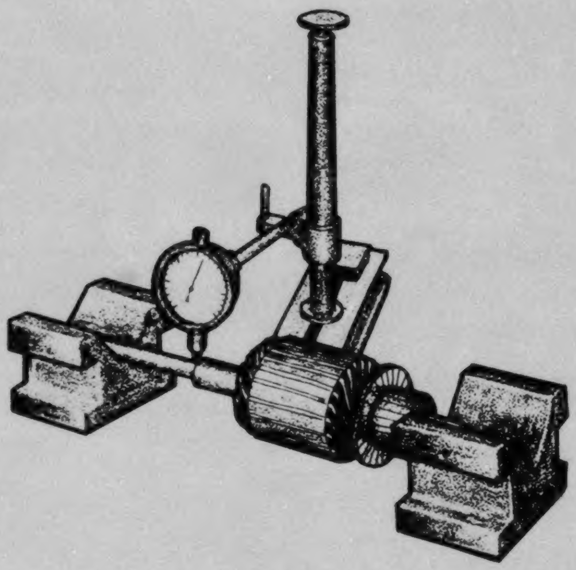
STARTERS



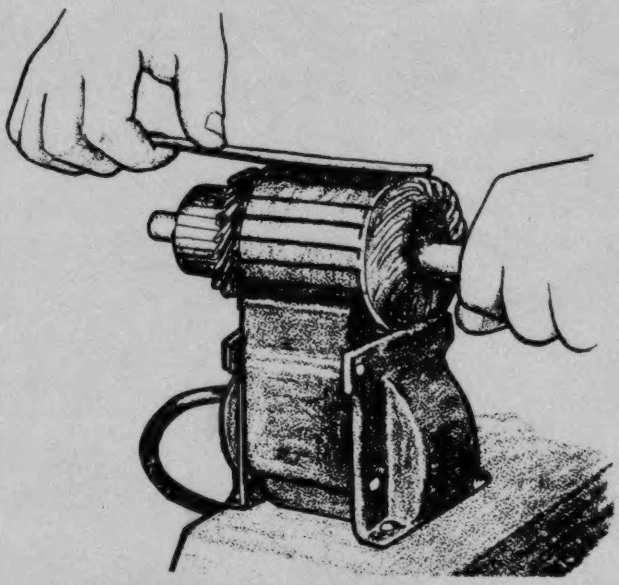
ARMATURE GROUND TEST



FIELD COIL GROUND TEST



SHAFT TEST



ARMATURE SHORT CIRCUIT TEST

GENERAL AGRICULTURAL MECHANICS

Unit D: Servicing the Cooling System

Topic 1: Functions and Service of Different Types of Cooling Systems

Suggested Procedures and Activities: An exhibit made up of a water pump, thermostat, radiator cap, cooling system hoses, drive belts, and corrosion inhibitors may be used as teaching aids during the topic discussion.

1. Purposes of An Engine Cooling System

The functions of the cooling system are to remove excess heat that is generated by the combustion of fuel in the combustion chamber and to regulate the temperature of the engine. It is estimated that about 40 percent of the heat is transmitted through the cylinder walls and removed by the cooling system. Excessive heat in an engine may cause engine problems such as oil breakdown, formation of varnish, sticking and burned valves, engine knock, and a cracked engine head or block. Actually an engine generates too much heat; therefore, if excessive heat was not removed, overheating may "burn up" the engine.

Gasoline engines operate efficiently when the temperature is 165 to 185 degrees F. Diesel engines operate at 180 degrees F. and above. Engines that operate on heavy type fuels may perform more efficiently at about 190 degrees F. The cooling system does not eliminate all of this heat that is generated by the engine. About 30 percent of the heat in the engine is converted into power to move the tractor. Another 30 percent passes through the exhaust and is wasted. Thus, about 40 percent is removed by the cooling system.

Transparency No. 1

2. Types of Cooling Systems

a. Forced Circulation or Closed System - Water or other types of coolants are forced to circulate within the cooling system by means of a water or coolant pump. In this type of system coolant is forced from the bottom of the radiator by the coolant pump to jacket spaces around the cylinders and through holes around the cylinder head and then through a hose to the top of the radiator. Most tractors are equipped with a suction-type fan; that is, air is pulled through the radiator and pushed over the engine. Usually the fan is located about 2 1/2 inches from the radiator core. Slow moving farm machinery and machinery that might pull an excessive amount of harmful materials through the radiator is equipped with a blower type fan. The air is pulled over the engine and pushed through the radiator.

The water passes through radiator tubes that are surrounded by air passages and fins where most of the heat is removed. As the water enters the bottom of the radiator, it flows through a rubber tube into the water pump to repeat the cycle.

The flow of water in the cooling system is controlled by a thermostat which is located at the point where the heated water leaves the engine. The thermostat opens and allows water to circulate in the cooling system when the coolant reaches the proper temperature. If the thermostat is closed on a cold engine, the water circulates through the engine block only.

The radiator pressure cap serves a very important function in the pressure type forced circulation system. The engine can operate at a higher temperature without losing the water by evaporation or boiling it out. The cap also permits atmospheric air to enter the radiator as the system cools down. Most caps are built with a spring-loaded valve that functions under a 6 to 7 pound pressure per square inch. The pressure cap will cause the heat to increase from 212 degrees F. (boiling point) to about 230 degrees F. The higher temperature causes the engine to operate more efficiently.

b. Air Cooling System - Most small engines are air-cooled. In order to facilitate cooling, the cylinder and cylinder heads are made with fins or ridges. These fins and ridges make it possible to have thinner walls for the cylinders and cylinder heads and at the same time increase the area exposed to the circulating air around the engine. The fins on the flywheel serve as a fan to blow air into the hot parts of the engine. Blower shrouds and baffles are used to direct the air flow.

c. Thermosiphon System - This system is made up of all cooling parts of the forced - circulation system except the water pump and thermostat. The circulation of water in this cooling system is caused by its expanding and becoming lighter as it is heated. The hot water works from the water jackets to the radiator where it contracts due to cooling. Contracting causes the water to become heavier and descend in the cooling system to the engine. The rate of circulation depends upon the heat of the engine.

Transparency No. 2

3. Cooling System Tests

There are three tests that can be used to determine certain malfunctions in the cooling system. These tests are: system pressure, radiator cap, and thermostat. Steps to observe in making the tests include:

a. Use a pressure tester and connect it to the radiator cap location after the radiator has been filled to about 1/2 inch of the neck with water or coolant. Slowly build up pressure in the system by squeezing the rubber bulb several times. The pressure must not exceed the recommended pressure for the radiator. Pressure markings are usually given on the radiator cap. After the system is pressurized check the gauge to see if the pressure holds steady. At this point remove the tester (pressure pump) and operate the engine until it reaches the normal operating temperature. Pressurize the system the second time and check for leaks.

b. Pressure cap functions are also checked by using the pressure tester. Usually the cap pressure should be within one and one-half pounds of the manufacturer's specification.

c. The thermostat may be tested as follows:

    (1) Place a thermometer in a container that can be heated. Suspend the thermostat so that it will not touch the edges or bottom of the container. The thermometer should also be suspended in the container.

    (2) Stir the water as it is being heated in the container. The thermostat should begin to open at the temperature found stamped on its body. Of course, this could vary (plus or minus) 10 degrees F. It should open at 22 degrees F. above the temperature rating found on the thermostat. The closing action should be observed after the thermostat is removed from the container.

Transparencies Nos. 3, 4, and 5

4. Further Checking and Adjusting Parts of the Cooling System

a. Fan and Fan Belt

(1) Check the fan for bent blades and the closeness of blades to the radiator core. If the blades are not properly adjusted, inefficient cooling may result and the fan may be out of balance. If the blades cannot be properly adjusted remove and replace the entire fan.

(2) Methods to follow in checking and adjusting the fan belt are:

(a) Inspect the belt for base cracking, worn sides, broken cords, damaged edges, torn cover, and slip burn. Belts that show these symptoms are usually replaced.
(b) Adjust the belt to the proper tension. A belt that is too loose will cause slippage which in turn may cause the engine to overheat, belt burned spots, and belt cover wear. However, if the belt is too tight, the bearings may be damaged, the belt and sheaves may become over heated and the belt may be caused to stretch. Tension adjustment may be made by using a straight edge placed on the two pulleys and forcing the belt down with a ruler. One-half to three-fourths inch deflection is usually standard for a fan belt.

(c) If necessary, use a straight edge to check the alignment of the sheaves (sides of the pulley). Also check to determine whether or not the belt rides on the sides of the sheaves, and not in the bottom of the pulley groove.

(3) Inspect the radiator for the following conditions: bent or damaged fins, dents on the frame and tank, fractured seams, cracked tubes, clogged or bent overflow tube, and deteriorated rubber cushioned washers. If the radiator seems to be clogged, causing the engine to run hot, remove it and have the radiator flow tested. This type of test will show the number of gallons of water passing through the radiator per minute. If the flow rate does not meet the manufacturer's specifications have the radiator cleaned. Cleaning involves placing the radiator in a cleaning tank and boiling until all rust, scale, and oil film are removed. It is then flushed with clean water.

The radiator may be tested for leaks after it has been cleaned by plugging the outlet pipe and overflow tube and then forcing 7 to 10 pounds of compression into the radiator as it is submerged in water. Bubbles will identify the location of leaks. Leak surfaces should be soldered. Fins should be straightened.

(4) A defective radiator cap should be replaced. Check the pressure and vacuum valves at the same time the radiator is tested. The vacuum valve is located at the bottom of the cap, and it prevents a vacuum in the system when the engine cools. The rubber faced pressure valve is located just above the vacuum valve. Inspect the valves for freedom of operation and cleanliness.

(5) Examine cooling system hoses by squeezing them to see if they are hard and brittle or soft and swollen. A loose or cracked hose may admit air into the cooling system causing rust to accumulate faster than normal. This type of hose condition may also permit coolant to escape. Rubber particles from old deteriorated hose can cause radiator tubes to clog. It is a good practice to examine hoses once or twice yearly.

To properly install or replace a hose, clean the pipe connections by wiping with a clean cloth and then apply a layer of non-hardening hose sealing compound over area where hose is to be fitted. Cut the hose to the proper length if it appears too long. Usually the ends are cut square. Place hose clamps on the hose at connecting locations and then place hose on connections. Move hose by twisting back and forth to seat. Tighten the hose clamps. Tight clamps will prevent the hose from being blown from the radiator or engine block.

Radiator hoses are either the molded type or the flexible accordion type. Some tractors are equipped with hoses that have a spiral wire inside to prevent collapse. All hoses should be replaced with the type that is recommended for the cooling system. A hose fitting should be treated with a sealer before the hose is clamped on it.

(6) Replace a damaged or corroded thermostat. If a thermostat has a damaged bellows, the coolant on the inside may be lost, causing the valve to stick in the open position. If there is doubt about the thermostat functioning properly, remove it and check for rust deposits. If it appears to be damaged by rust replace the thermostat with the type specified by the engine manufacturer. Not all engines are equipped with the bellows type thermostat. There are bimetallic and solid expansion thermostats used in engines.

(7) The water pump may be called the heart of the cooling system where this type of forced flow is provided on an engine. Most modern tractor and other equipment engines using the forced

circulation system require little water pump maintenance. Pump bearings are usually sealed and self-lubricated. However, it is advisable to check for coolant leaks in the housing, damaged seals, and broken impeller vanes. Excessive leakage will cause rust and corrosion which will cause damage to shaft and bearings. Leakage usually occurs at the shaft seal, pump housing gasket, and thrust washer seal. It is usually cheaper to repair a water pump instead of replacing it with a new one.

5. Flushing and Winterizing the System

a. Flushing the entire system is a very important step for protecting the engine against rust and other deposits and protecting the engine against freezing temperatures. Steps to follow when flushing a cooling system are:

(1) Operate the engine long enough to open the thermostat. If the engine is not operated the proper length of time, all the coolant cannot be removed from within the water jacket.

(2) Open all drain points to remove the coolant. Some systems have more than one drain plug. While draining the system, if rust and scale appear in the coolant add an acid-base cleaner following the manufacturer's instructions. It may be necessary to add an acid neutralizer after completely draining the acidized coolant. The system should be filled with water before adding the neutralizer. Again operate the engine with the neutralizing water as a coolant, drain, and flush again with water.

b. Usually it is advisable to drain, clean, and flush a radiator just before adding anti-freeze each year. This practice is accomplished before freezing weather. It is recommended that anti-freeze be replaced each year due to the rust inhibitor breaking down. Anti-freeze is added as follows:

(1) If the radiator contains clean soft water, drain enough of this coolant from the radiator to add the necessary amount of anti-freeze. The anti-freeze should contain a rust inhibitor.

(2) Operate the engine until the normal operating temperature is reached. This action will permit the coolant to circulate in the entire cooling system. Normal operating temperature causes the thermostat to open, allowing the coolant to flow to

all parts of the system. A winter coolant usually consists of a mixture of water and anti-freeze (ethylene glycol base).

(3) In order to determine the ratio of water to anti-freeze use a special hydrometer to make the test. The coolant is drawn into the hydrometer several times and released back into the radiator. This equalizes the hydrometer temperature with the coolant. The coolant is then drawn into the hydrometer and a reading taken. Follow the manufacturer's directions for making a proper test.

It is not necessary to use a coolant during the non-freezing seasons, but it is necessary to add a rust inhibitor when using soft water. Water has a tendency to absorb heat more rapidly than anti-freezes; therefore, it should be used as a coolant, except during winter months. It is not considered convenient to use water as a coolant throughout the year due to having to drain the cooling system each time after work during the freezing season.

The dry type cooling system needs little service of any kind. The only service would be the cleaning of any clogged fins or louvers on the head and sides of the cylinders. Residue build up in the air shroud should be kept to a minimum.

References:

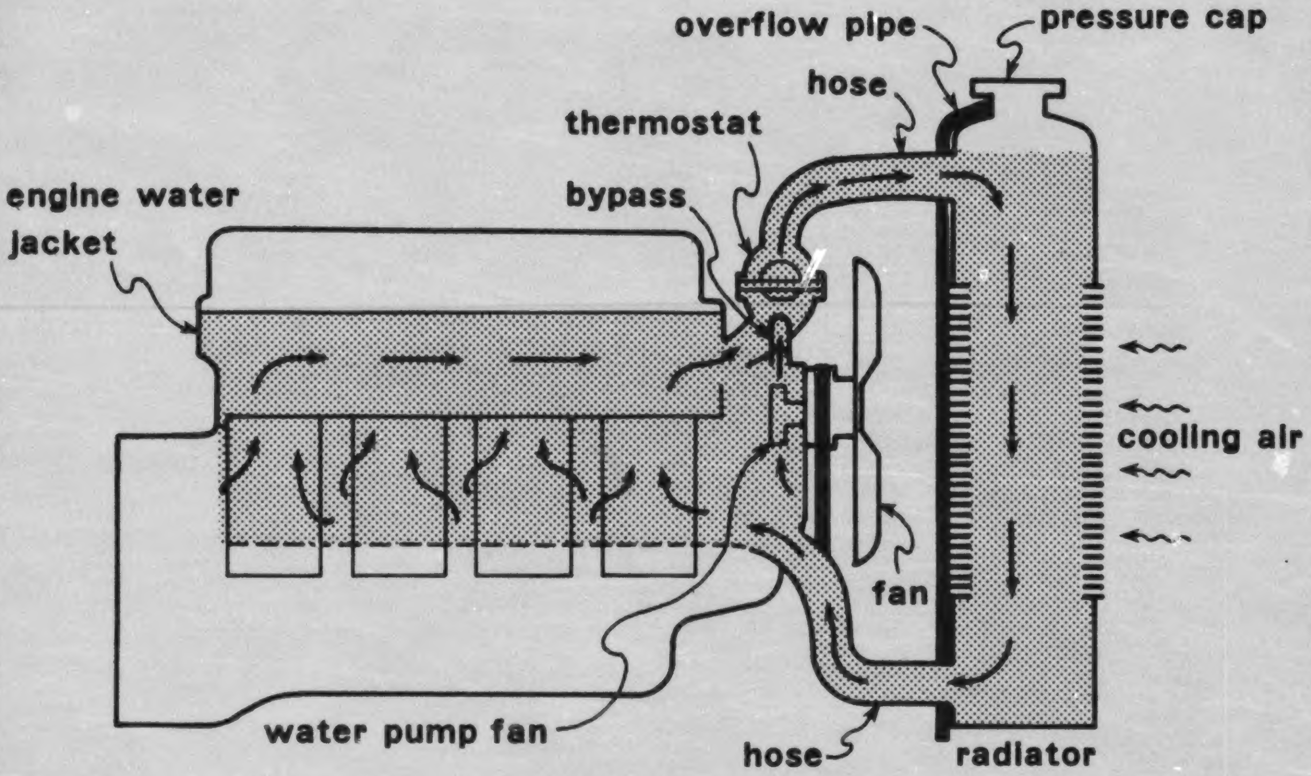
1. Promersberger, William A., and Others, Modern Farm Power, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1971

2. Stockel, Martin W., Auto Service and Repair, The Goodheart-Willcox Company, Inc., South Holland, Illinois, 1969

3. "Fundamentals of Machine Operation - Preventive Maintenance", Deere and Company, Moline, Illinois, 1973

4. "Tractor Maintenance, Principles, and Procedures", American Association for Vocational Instructional Materials, Athens, Georgia, 1975

TYPES OF COOLING SYSTEMS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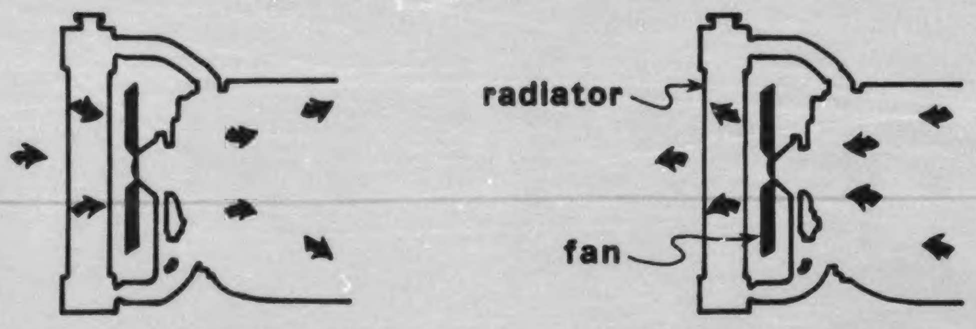
pressure cap
hose
thermostat
engine water jacket
bypass
cooling air
fan
water pump fan
hose
radiator

FORCED CIRCULATION

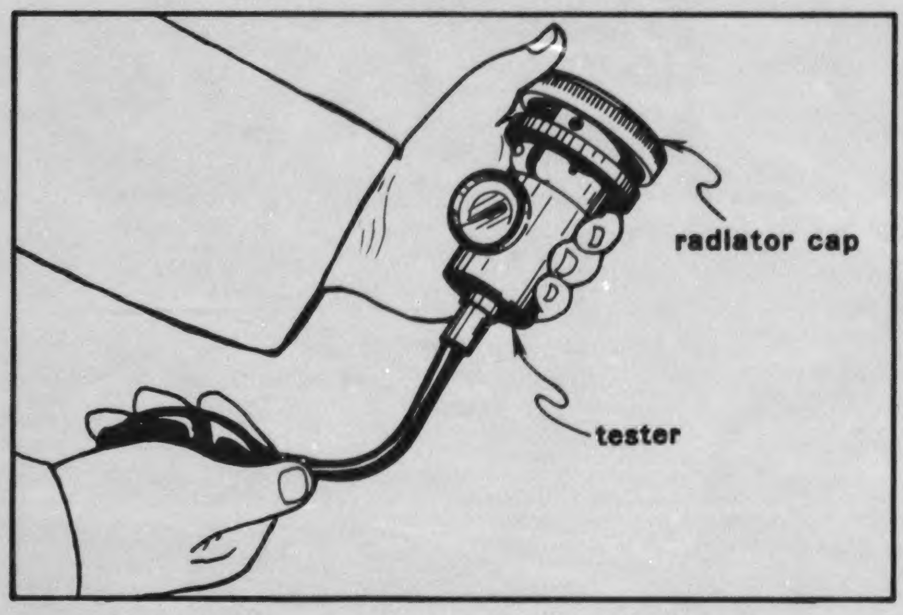

radiator
fan

SUCTION TYPE FAN

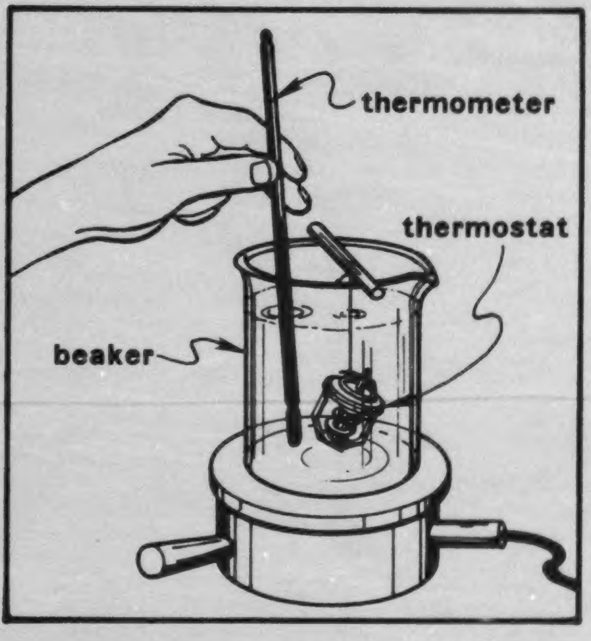
BLOWER TYPE FAN

TYPES OF AIR MOVEMENT

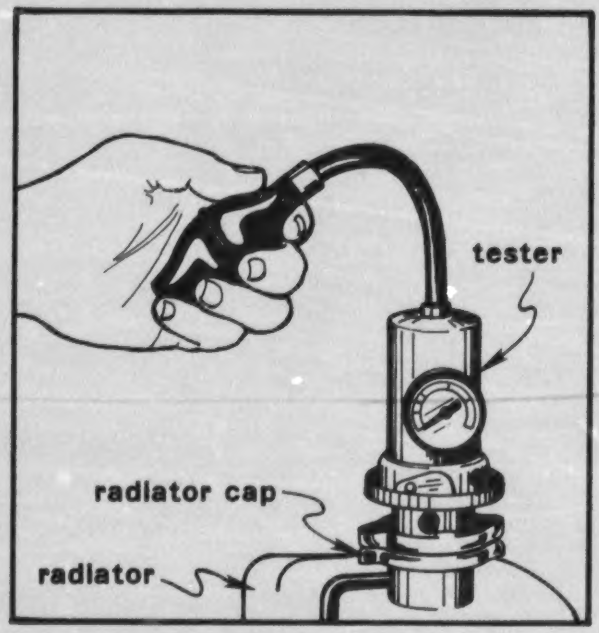
TYPES OF TESTS AND TESTING EQUIPMENT


radiator cap
tester

TESTING CAP PRESSURE

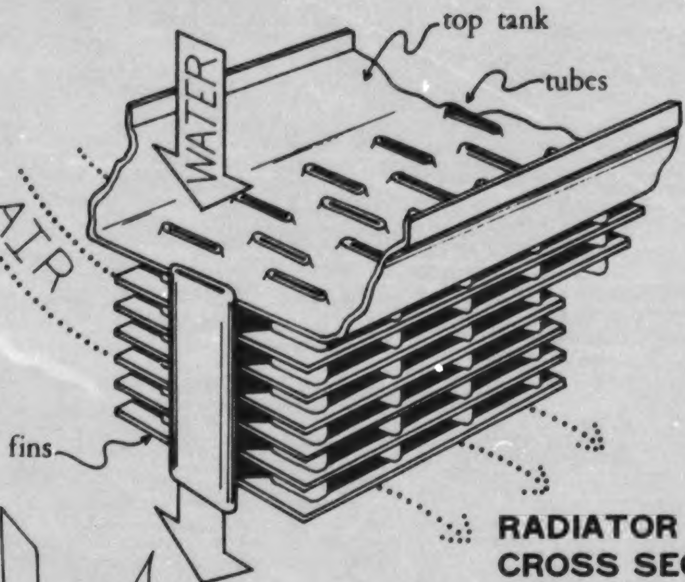

thermometer
thermostat
beaker

TESTING THERMOSTAT

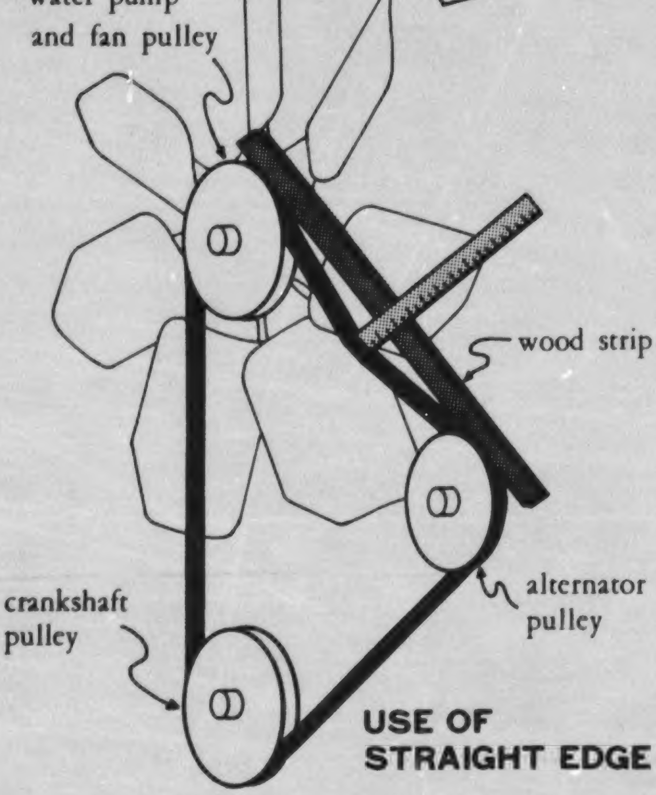

tester
radiator cap
radiator

TESTING PRESSURE IN COOLING SYSTEM

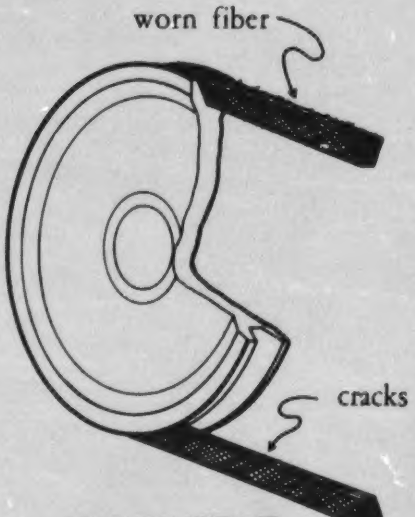
CHECKING AND ADJUSTING PARTS OF COOLING SYSTEM


top tank
tubes
WATER
AIR
fins

RADIATOR CROSS SECTION

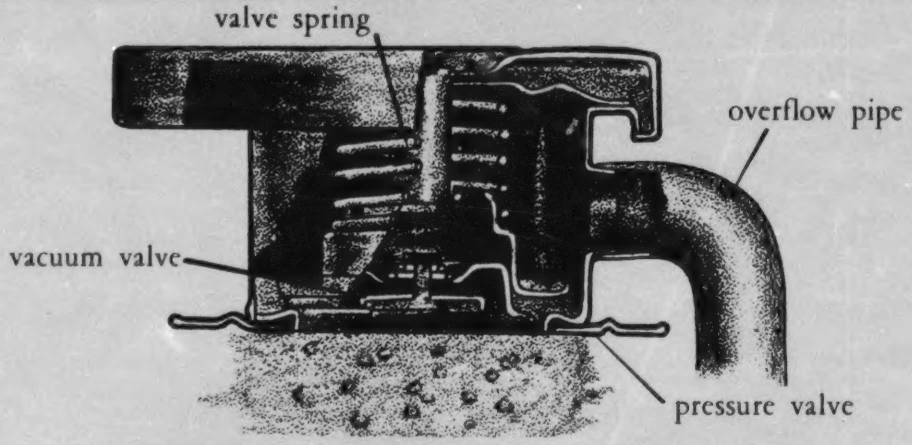

water pump and fan pulley
wood strip
alternator pulley
crankshaft pulley

USE OF STRAIGHT EDGE

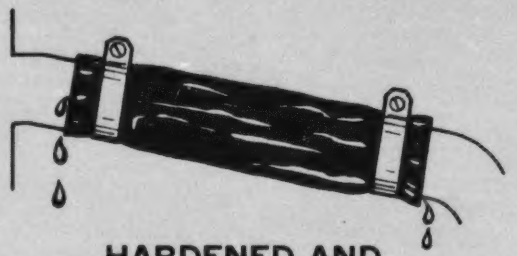

worn fiber
cracks

WORN BELT

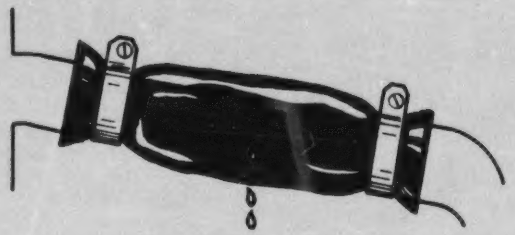
CHECKING AND ADJUSTING PARTS OF COOLING SYSTEM


valve spring
overflow pipe
vacuum valve
pressure valve

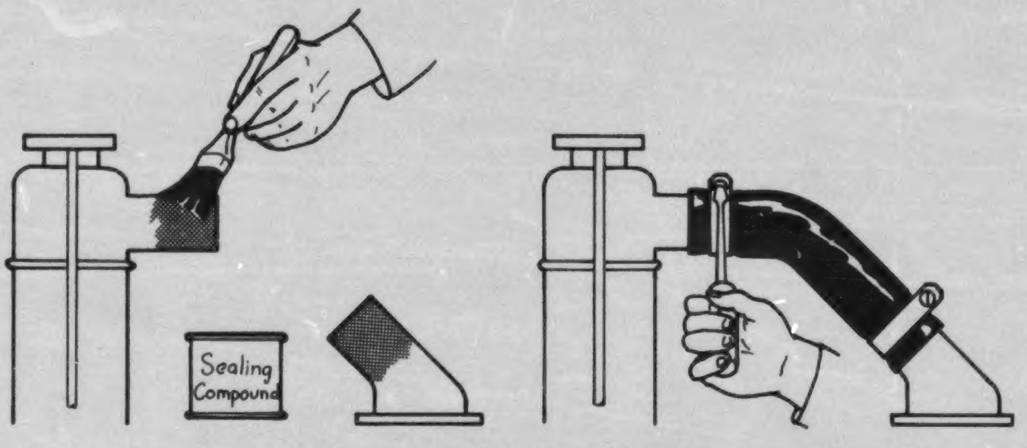
RADIATOR CAP ASSEMBLY



HARDENED AND CRACKED HOSE

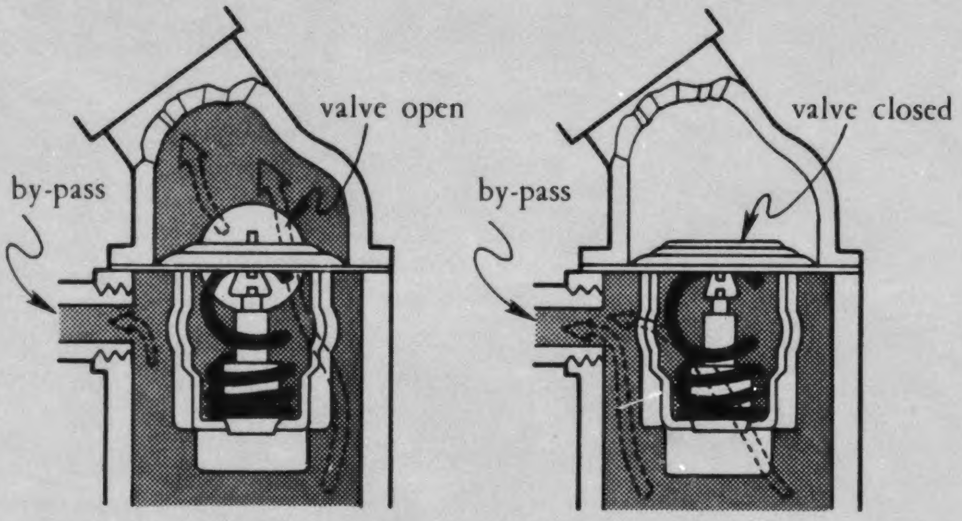


SOFT AND SWOLLEN HOSE


Sealing Compound

NEW HOSE INSTALLATION

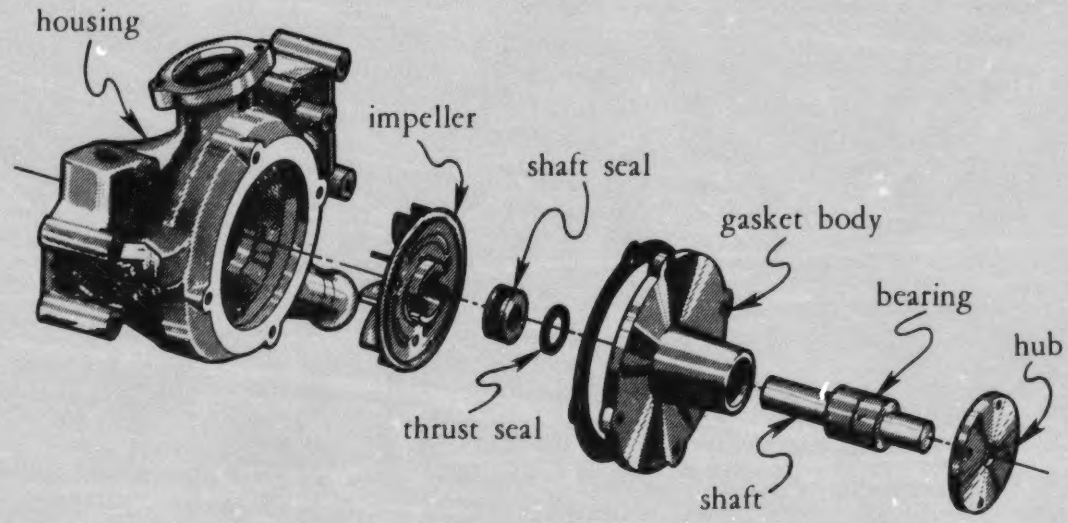
CHECKING AND ADJUSTING PARTS OF COOLING SYSTEM


valve open
by-pass
valve closed
by-pass

HOT COOLANT FLOW

COLD COOLANT FLOW

THERMOSTAT OPERATION


housing
impeller
shaft seal
gasket body
bearing
hub
thrust seal
shaft

WATER PUMP ASSEMBLY

GENERAL AGRICULTURAL MECHANICS

Unit E: Servicing Fuel and Air Systems

Topic 1: Replacing Lines and Fittings

Suggested Procedures and Activities: Samples of lines (tubing and hose) and fittings will be helpful during the classroom discussion.

1. Importance of Tubing, Hose, and Fittings Used on the Fuel and Air Systems

   a. Tubing and hose are found on many parts of the fuel system. There are several kinds and sizes of tubing and hose used to transfer fluids, gases, and air and to create vacuums on engines and engine parts.

   b. Major locations of tubing or hose on the three fuel systems are as follows:

      (1) Gasoline System - Fuel tank to fuel pump, fuel pump to fuel filters, and fuel filters to carburetor.

      (2) L. P. Gas System - Fuel tank to liquid fuel filter, liquid fuel filter to high pressure regulator, high pressure regulator to vaporizer, vaporizer to low pressure regulator, and low pressure regulator to carburetor.

      (3) Diesel System - Fuel tank to fuel transfer pump, fuel transfer pump to fuel filters, fuel filters to fuel injection pump, and fuel injection pump to injection nozzles. The diesel also has a no-pressure fuel return line that begins at the injection pump extending to each injection nozzle and back to the tank. This leak-off line is light weight. A medium weight line is used between the fuel tank and injection pump. Heavy weight or high pressure lines are used from the injection pump to the injectors.

2. Types of Tubing and Hose Materials

   a. Materials used for tubing are steel, annealed stainless steel, copper, annealed copper, aluminum, nylon, and polyethylene. Normally steel and copper are used on most tractor engines, and steel is considered the best type of material for tractor application. Copper is more easily cut and shaped. Plastic (polyethylene and nylon) tubing will not carry high pressures and withstand excessive heat. However, it can be used as fuel lines where these conditions do not exist. Aluminum tubing, like copper, is rust resistant, easy to bend, and forms good joints, but it will break under continuous vibration conditions.

b. The base material for hose is rubber. Fuel system hose has a close knit fabric in the inner wall. The inner rubber sidewalls are made thick to prevent collapse under vacuum conditions.

Transparencies Nos. 1 and 2

3. Types of Tubing Connections

The three basic types of tubing connections are:

a. Flare - The end of the tubing is spread (flared) outward at an angle. The angle of the flare may be 37 or 45 degrees. The flare may be single or double lap. The double lap flare is used on double wrapped brazed steel tubing.

b. Compression - A sleeve is compressed against the tubing as the body fitting and nut are screwed together. Compression fittings are not used on high pressure lines such as power brakes or steering. This type of fitting may be used on most fuel and lubrication lines.

c. Pipe Fittings - Pipe fittings have tapered threads which make a leak-proof joint when tightened on tubing or pipe. They are used to branch lines or connect two or more lines, attach tubing to the brake cylinder, carburetor, fuel pump, and oil filter, and connect tubing or pipe to other parts of the machine. The typical fittings are: connectors, elbows, unions, T-fittings, bushings, plugs, nipples, distribution blocks, and valves.

Transparency No. 3

4. Installing Tubing

Practices to follow when installing tubing are:

a. Make bends in the tubing to avoid straight runs. Vibration or shifting of parts at each end of the straight run connection will cause a strain on the connection.

b. Use mounting clips or mounting bolts to connect long runs to the body or parts of the machine. Valves, distribution blocks, and long runs must be supported.

c. Align tubing ends with pipe fitting. Aligned ends will facilitate installation, prevent cross threading, and prevent leaks. Cross threading will permanently damage the connection.

d. Protect tubing from excessive heat by bending it around the heat source, installing a baffle, and/or insulating the tubing. Tubing too close to the exhaust system will overheat.

e. Connect both ends of the tube before tightening the connections. The long end should be connected first. End nuts should not be tightened too tight. Use torque valves if necessary.

f. Select proper tubing and fittings for the job. For example, flare fittings are selected for high pressure applications such as brakes. Also, flare fittings are to be used on the type of tubing that can be flared (aluminum, copper, and steel).

Transparencies Nos. 1, 2, 3, and 4

5. Assembling Fittings and Hose

a. Flared Fittings - The tubing is cut square, reamed, and flared to either a 37 or 45 degree angle. A tube cutter, flat reamer, and flaring tool are necessary to fit a tube for use. A nut should be placed on the tubing before it is flared or at least before both ends are flared.

Thin wall and soft tubing can be bent by using a spring tube bender. Stiff tubing should be bent with a lever type mechanical bender. Usually the fitting nut is in place before the tube is bent. Precautions should be observed in order to avoid kinking or flattening the tube in the bending process.

The tubing should be aligned with the fitting and the flare forced against the fitting seat. The nut is first run up finger tight and then tightened with a flare nut wrench.

b. Compression Fittings - After the tubing is cut, the nut is placed on the tubing. The sleeve is forced on behind the nut. The end of the tubing is aligned and placed in the fitting body as far as it will go. The tubing should be held in place and the nut drawn up finger tight. A flare nut wrench is used in the following manner:

Tighten the nut until the sleeve grasps the tubing.

Turns for tightening the nut and sleeve -

Size of Tubing (Inches)	Additional Turns
1/8, 3/16, and 1/4	1 and 1/4
5/6	1 and 3/4
3/8 one inch	2 and 1/4

c. Pipe Fittings - Before connecting pipe fittings, apply thread sealing compound very sparingly. Tighten fittings by hand and then tighten three turns with a fitting wrench.

d. Fuel system hose on gasoline operated machines operates under low pressure. The hose may be made of Buna N, Neoprene, or other synthetic material. These are constructed with heavy sidewalls to prevent collapse.

Fuel system lines should not be confused with fuel system hose. Fuel system lines are usually made of steel. Recently polyethylene has been replacing steel to transfer the fuel from one place to another.

The following steps may be used for installing a low pressure fuel hose:

(1) Select a hose that has reinforced sidewalls and will withstand gasoline.

(2) Clean hose fitting and cut the hose to a desired length (cut slightly longer than the distance between connections).

(3) Slip hose over hose fitting and check hose for snugness and coverage over the fitting.

A medium and high pressure hose is braided. It is twisted on the fitting counterclockwise, and the nipple for the other end is screwed into the fitting.

6. Proper Hose Installation Precautions

Installing hose is similar to installing tubing; that is, the same precautions must be observed. These precautions are:

a. Do not connect a hose so that it will be taut. Slack should be allowed to prevent the hose from bulging and weakening under pressure.

b. Route the hose away from heated areas such as the manifold. If it is necessary to connect a hose near a heated surface, shield it from the heat.

c. Protect the hose from moving parts by clamping or bracketing it away from these parts. Wire springs may be used to keep the hose away from sharp edges or moving parts.

d. Avoid twisting the hose when installing it. Twisting will weaken the hose and cause the fittings to loosen. The fitting should be tightened on the hose. The hose is not to be tightened on the fitting.

e. Route the hose to reduce the amount of bend. A large size low pressure hose can be bent to a greater degree than a high pressure small hose. All bends should be gradual and not sharp.

f. Usually long loops are not necessary in hose connections. Angle fittings may be used to reduce the size of a loop. Usually extra hose gets in the way of some machine parts.

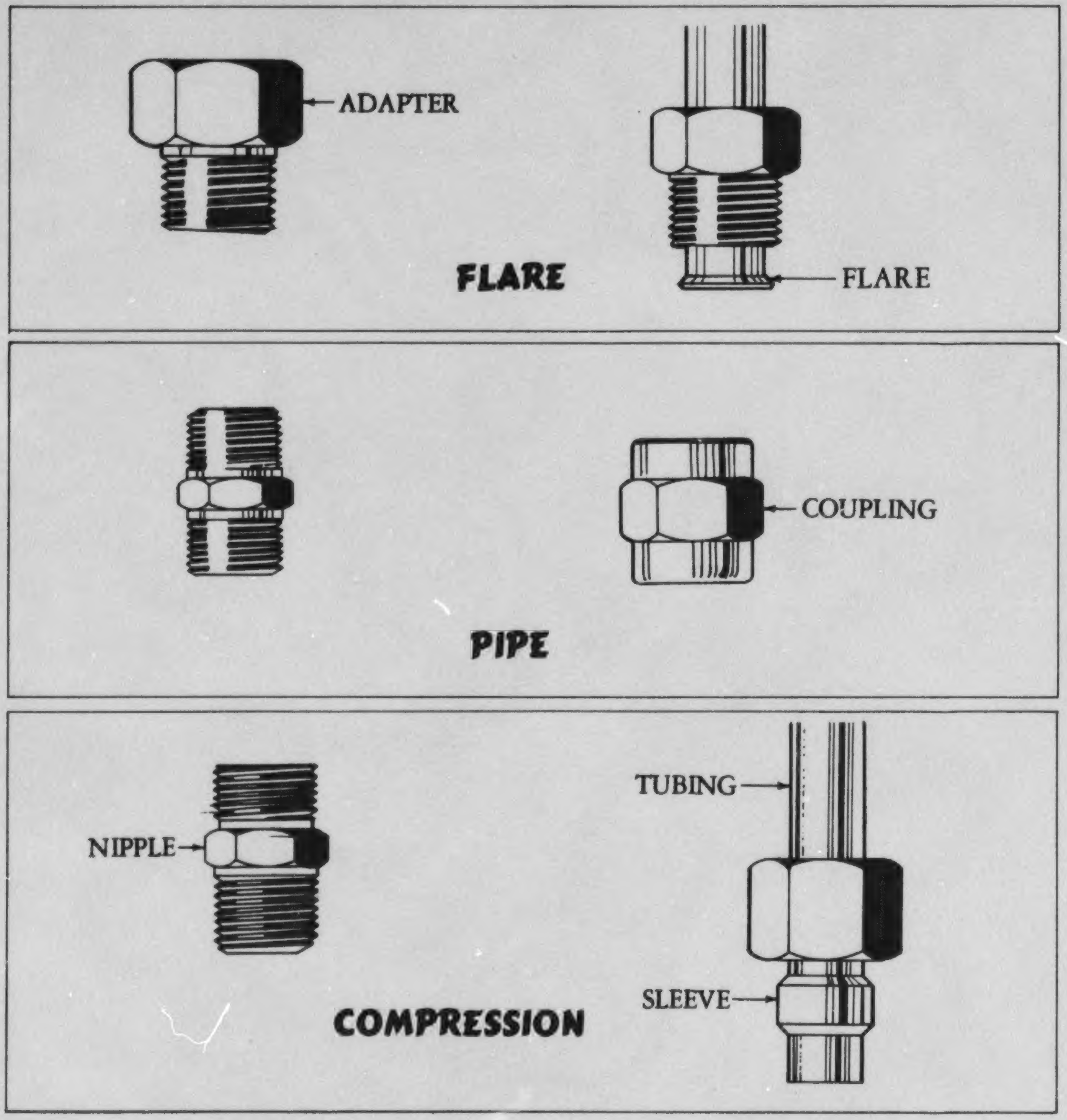
g. Use the proper type of hose for the jobs. The machine service manual will give the type, size, and pressure strength of the hose to be used when overhauling the machine.

References:

1. Stockel, Martin W., Auto Service and Repair, The Goodheart-Willcox Company, Inc., South Holland, Illinois, 1969

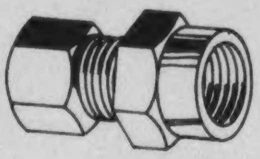
2. "Fundamentals of Machine Operation - Preventive Maintenance", Deere and Company, Moline, Illinois, 1973

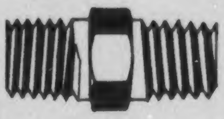
TYPES OF TUBING CONNECTIONS


ADAPTER
FLARE
FLARE
COUPLING
PIPE
TUBING
NIPPLE
SLEEVE
COMPRESSION

THREE TYPES-TUBING CONNECTIONS

TYPES OF TUBING CONNECTIONS


CONNECTOR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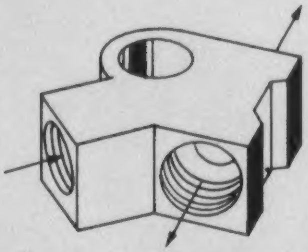
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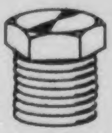
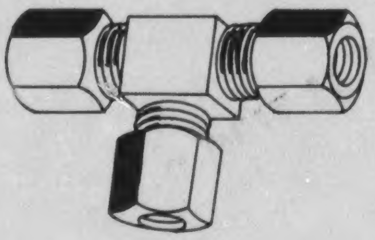
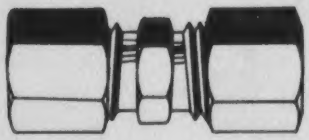
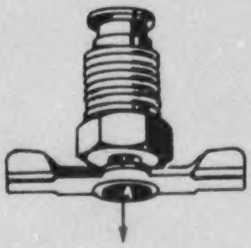
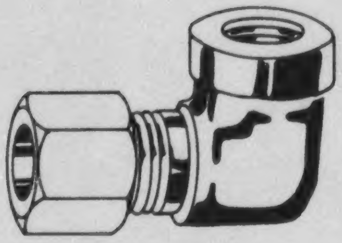
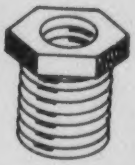

PLUG


T-FITTING


UNION

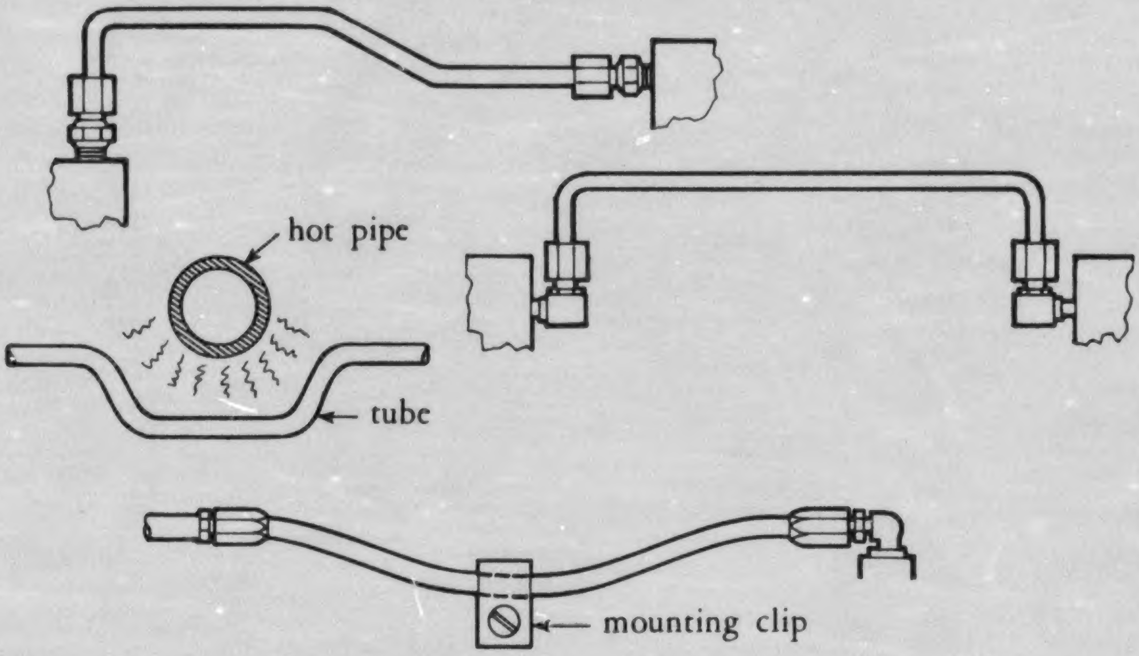

DRAIN VALVE


ELBOW

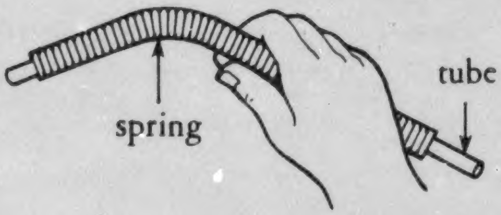

BUSHING

INSTALLING TUBING

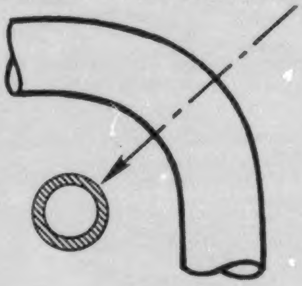
PROPER BENDS

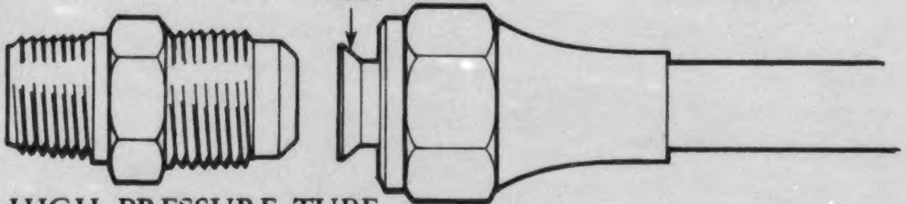

hot pipe
tube
mounting clip

BENDING WITH SPRING


tube
spring

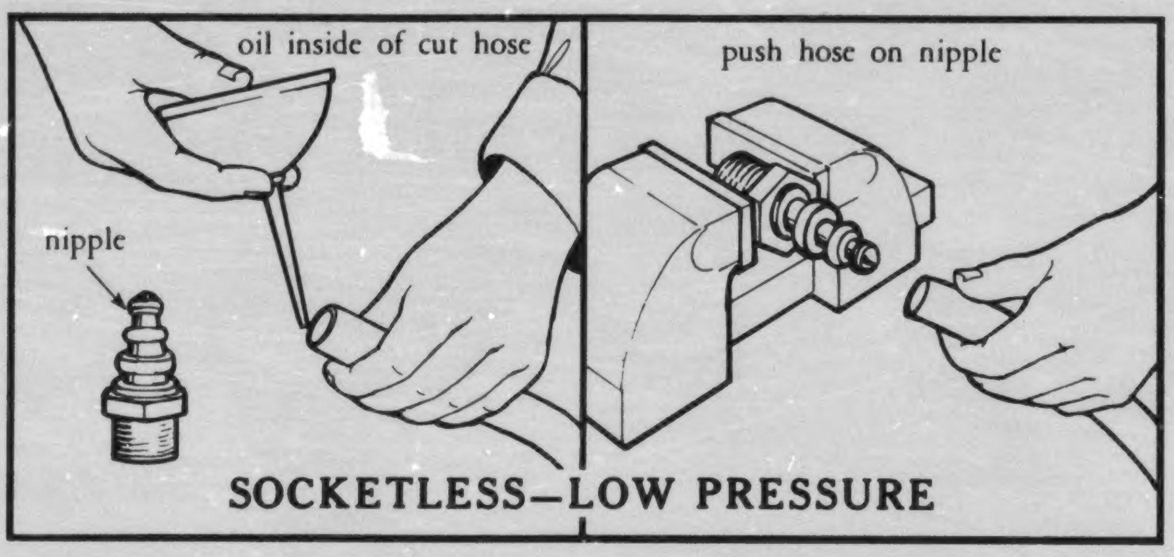
PROPER CORNER BEND



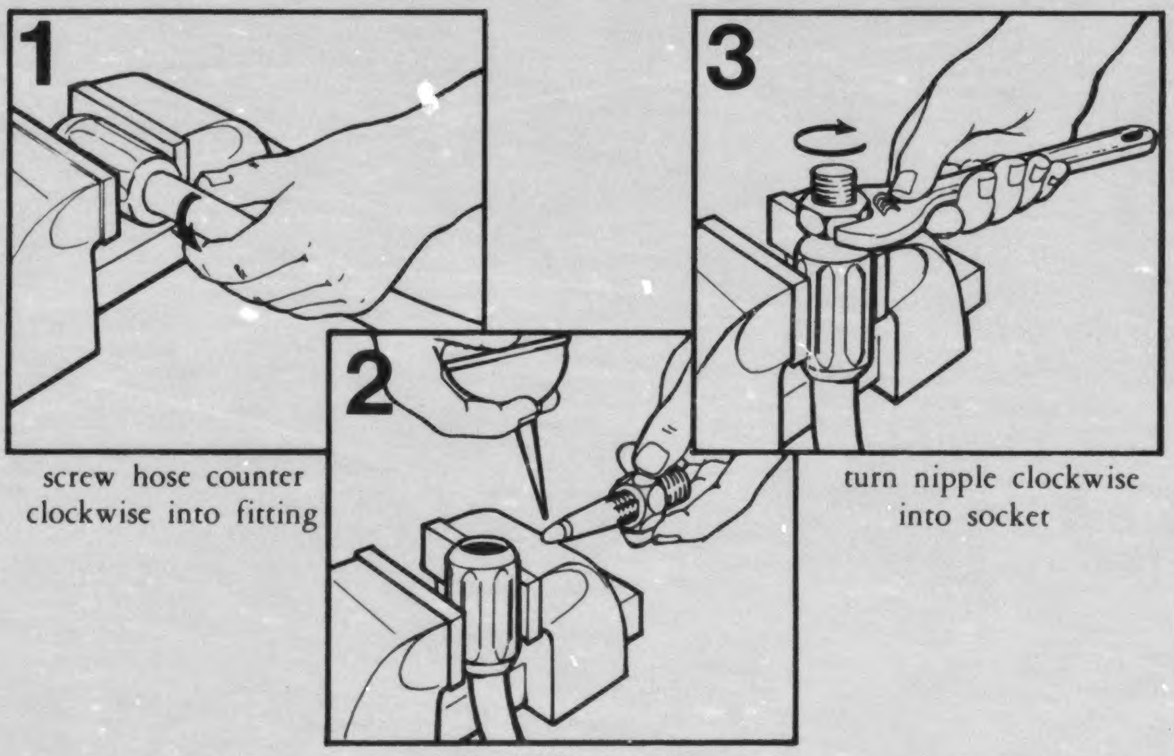


HIGH PRESSURE TUBE

ASSEMBLYING FITTINGS & HOSE


oil inside of cut hose
nipple
push hose on nipple

SOCKETLESS—LOW PRESSURE



screw hose counter clockwise into fitting

turn nipple clockwise into socket

oil nipple threads

SOCKET & NIPPLE—MEDIUM & HIGH PRESSURE

GENERAL AGRICULTURAL MECHANICS

Unit E: Servicing Fuel and Air Systems

Topic 2: Servicing The Sediment Bowl and Fuel Filters

Suggested Procedures and Activities: If possible the three types of fuel filters (gasoline, diesel, and L. P. gas) should be used as teaching aids during the class discussion and at the time the transparencies are presented.

1. The Purpose of Using Filters

Fuel filters have a special function in engine operation. They are similar to air filters, in that, they help provide a clean fuel mixture to the engine. Water, dirt, and other foreign matter is taken out of the fuel and either deposited in a sediment bowl or absorbed in a filter element. Filters that are equipped with sediment bowls or sediment containers will allow water, dirt, rust, and other foreign matter that affects the jets of a carburetor to settle out. Moisture in L. P. gas causes rust, and it will cause excessive wear in diesel injectors.

The operator's manual usually recommends the service intervals to be observed. Service may vary from daily to once per year. Certain factors could be involved that would cause unscheduled service, such as dirty or watery fuel, scale and rust from the fuel tank and lines, and clogged or dirty screen or element.

Transparencies Nos. 1 and 2

2. Some Types of Fuel Filters and Their Use

a. Glass Bowl - This type of filter may be found on gasoline and diesel engines. The parts of a filter for a gasoline engine are:

(1) Sediment glass bowl

(2) Fuel strainer

(3) Filter cover

(4) Bail and jam nut

(5) Bowl gasket

(6) Shut-off valves

b. Metal Bowl - Metal bowl filters can be found on L. P. gas engines. The main filter parts include:

(1) Metal sediment bowl
(2) Screen
(3) Felt filter
(4) Drain plug
(5) Gasket

c. Metal Reservoir with Element - This type of filter may be found on gasoline and diesel engines. It consists of the following main parts;

(1) Reservoir
(2) Element
(3) Cover
(4) Cover nut assembly

d. Two-Stage Sediment Bowl Filter - This filter is found on diesel engines. It consists of two filters with different types of elements. The main parts of stage one filter are:

(1) Sediment bowl
(2) Drain plug
(3) Air bleed screws
(4) Cotton string element
(5) Screen
(6) Fuel inlet

The second stage parts consist of:

(1) Sediment bowl
(2) Drain plug
(3) Air bleed screws
(4) Paper element
(5) Fuel outlet

There are also single and third stage filters used on diesel engines.

3. Cleaning Sediment Bowl and Strainer For a Gasoline Fuel System

a. Turn off the gasoline supply. A shut-off valve may be located at the sediment bowl or fuel tank, then loosen jam nut holding the sediment bowl in place and remove the bowl with gasket from the filter head.

b. Lift the strainer screen from the bowl and wash it in a solvent. A carburetor cleaner solvent will remove varnish deposits on the screen.

c. Use a clean cloth dipped in the solvent to clean the sediment bowl. Dry the bowl with another clean cloth and remove any remaining lint.

d. Draw a small amount of fuel from the tank by opening the fuel valve and at the same time observe the rate of flow which will indicate whether or not the tank cap vent hole is clogged. The cap may be cleaned by washing it in a solvent.

e. After reassembling all filter parts, tighten the jam nut at the bottom of the bowl. It may be necessary to let the bowl fill before making the air-tight turn on the nut.

f. After assembly is made and the bowl is fitted tightly against the filter head, including gasket and strainer, open the fuel valve again. Operate the engine for a few minutes and look for leaks.

4. Cleaning a Fuel Filter on an L. P. Gas Engine

a. When cleaning only the strainer use the following steps:

(1) Turn off both the vapor and liquid valves located at the tank and then remove the drain plug located at the bottom of the filter container.

(2) Slowly open the vapor valve to force pressure into the fuel filter. This pressure should remove moisture and sediment from the bowl.

(3) After closing the vapor valve replace drain plug in the filter.

b. In order to thoroughly clean the fuel filter, use the following steps:

(1) Close both vapor and liquid supply valves.

(2) Slowly open the drain plug located on the bottom of the filter to relieve pressure.

(3) Remove the filter bowl, gasket, and element after loosening the nut that holds the bowl in place.

(4) Remove the filter element and wash in a solvent if it is the washable type. Wipe the sediment bowl clean using a clean cloth dampened in solvent. Dry the bowl with another clean cloth and check for lint

in the bowl that might have come from the cloth.

(5) Replace the element (a disposable type element should be replaced with a new one), gasket, and sediment bowl.

(6) Secure filter by tightening nuts that hold it in position, and open tank valves.

(7) Check for possible leaks by brushing soapy water on connections. If leaks appear, tighten connections. Leaks will show up in the form of bubbles. It may be necessary to replace fittings if tightening does not correct problem.

5. Cleaning a Diesel Fuel Filter

a. Steps to use when cleaning a system daily are:

(1) To remove foreign matter or water, first close the fuel tank valve and then remove the sediment bowl.

(2) Wash the bowl and strainer using the proper solvent and wipe dry using a lint-free rag.

(3) Replace the bowl and strainer using a new or good used gasket.

(4) Use the hand primer on the injection pump to bleed the filters after opening the cut-off valve to the fuel tank.

(5) Remove the drain plug located at the bottom of the bowl if water or dirt appears and bleed the filters at this time. It may be necessary to remove the plug at the fuel tank pump if water continues to appear.

b. Steps that may be used to change the filters after several hundred hours use (first stage about 500 hours and second stage about 1000 hours) are:

(1) Before removing the filter use a solvent to remove grease and dirt outside the filter and area around it.

(2) Remove the drain plug to empty filter of fuel and either remove the filter bowl or filter. This can be accomplished by either loosening bolts or clips that hold the filter in place.

(3) A nondisposable filter should be cleaned in a solvent. While cleaning check the filter element for damage. Disposable elements should always be replaced when servicing the filter unit.

(4) Clean the filter bowl with a solvent and wipe dry with a lint-free rag. Reassemble the filter unit and check proper gasket location. Tighten the drain plug or valve before opening the fuel cut-off valve.

(5) Bleed air from the fuel system by opening the bleed plugs. When dual filters are serviced, bleed the one near the fuel tank first. To force the air out of the lines and filters, open the fuel tank valve. If the fuel system is equipped with a hand priming pump, make several pumping strokes to free the system of air. When the fuel begins to flow through the bleed plug hole free of air bubbles, air should be removed from the system. Replace the bleed plug and start the engine.

(6) If the engine runs rough or is hard to start, bleed half of the injection lines by loosening injection line nuts (use care to avoid bending lines) and crank the engine with the starter until fuel in natural state (free of bubbles) flows around connectors. Retighten the connections and start the engine. The other half of the lines should free themselves as the engine runs.

References:

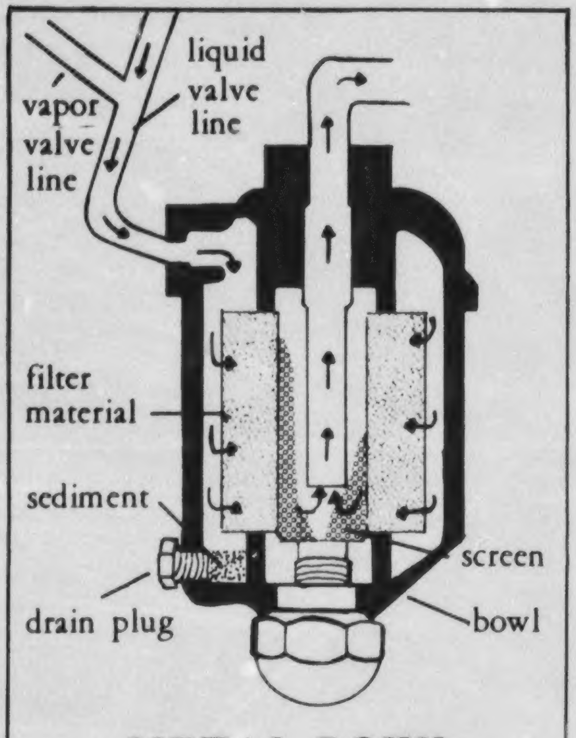
1. Stockel, Martin W., Auto Service and Repair, The Goodheart-Willcox Company, Inc., South Holland, Illinois, 1969

2. Toboldt, William K., Diesel - Fundamentals, Service, Repair, The Goodheart-Willcox Company, Inc., South Holland, Illinois, 1973

3. "Fundamentals of Machine Operation - Preventive Maintenance", Deere and Company, Moline, Illinois, 1973

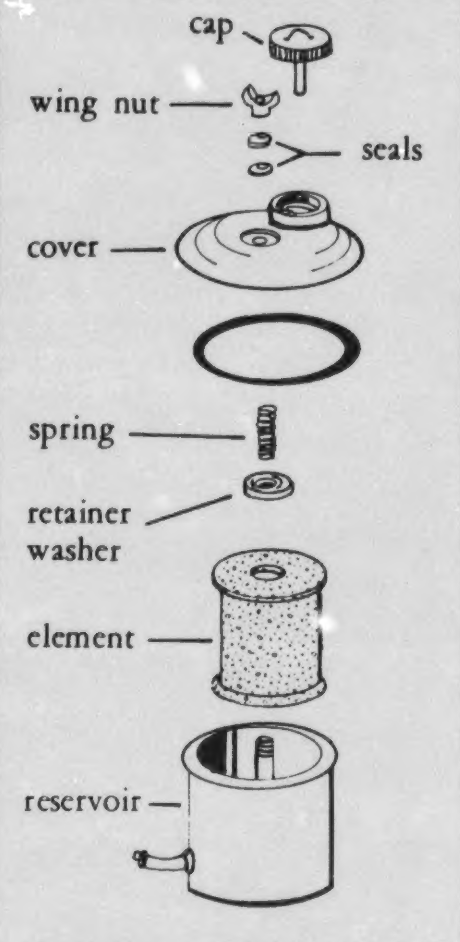
4. "Tractor Maintenance - Principles and Procedures", American Association for Vocational Instructional Materials, Athens, Georgia, 1975

TYPES OF FILTERS


liquid
valve
line
vapor
valve
line
filter
material
sediment
screen
drain plug
bowl

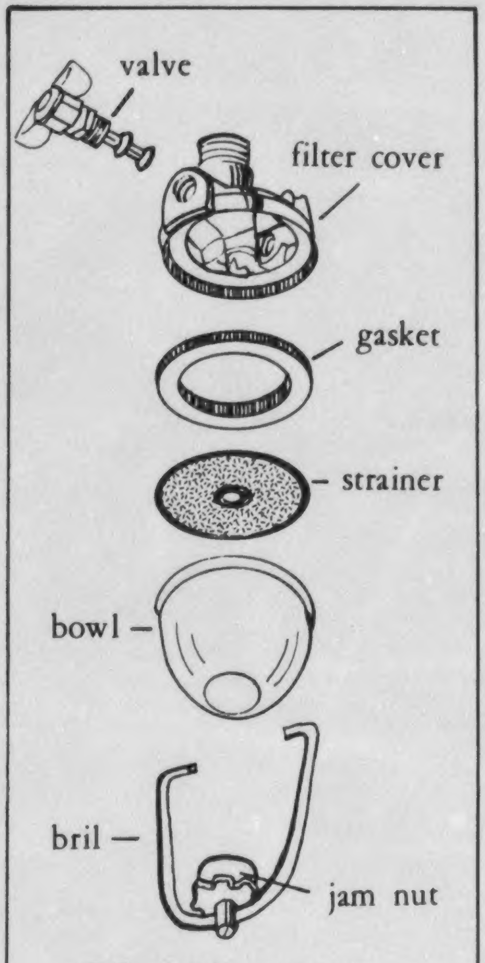
METAL BOWL

GASOLINE or DIESEL


cap
wing nut
seals
cover
spring
retainer
washer
element
reservoir

METAL RESERVOIR

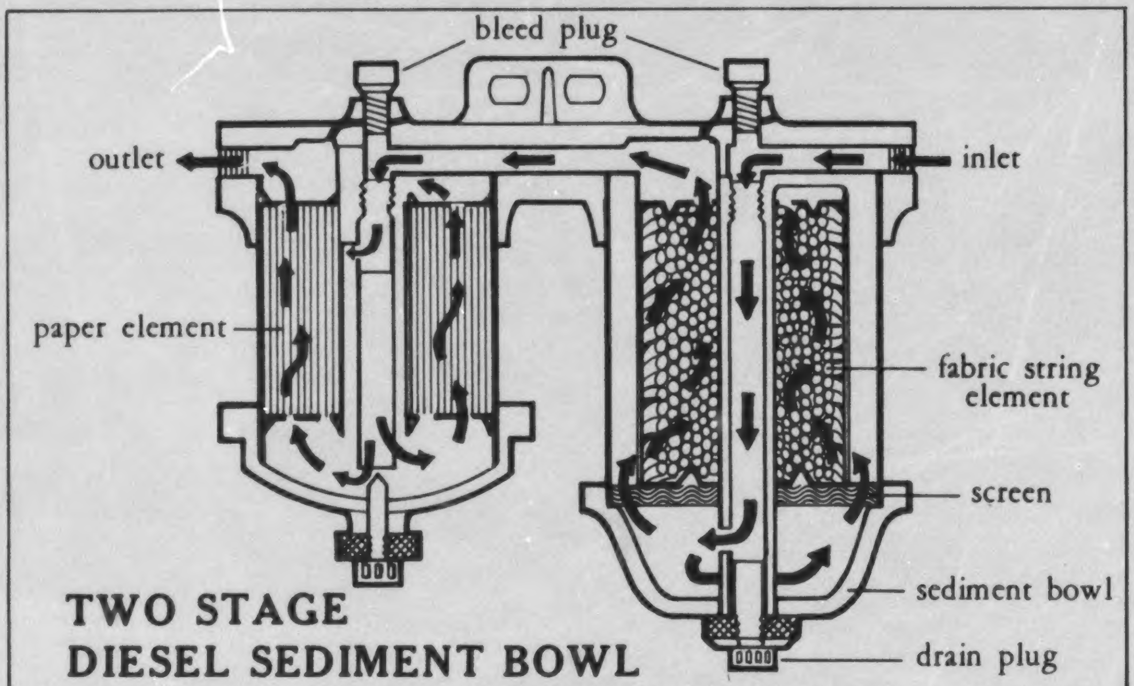
with ELEMENT


valve
filter cover
gasket
strainer
bowl
bril
jam nut

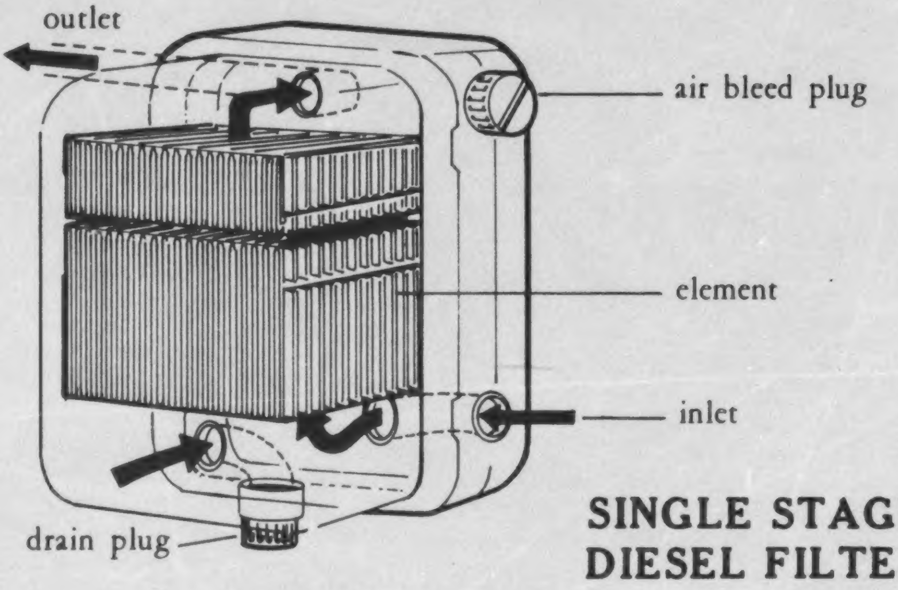
GLASS BOWL

LP GAS

TYPES OF FILTERS


bleed plug
outlet
inlet
paper element
fabric string element
screen
sediment bowl
drain plug

TWO STAGE DIESEL SEDIMENT BOWL


outlet
air bleed plug
element
inlet
drain plug

SINGLE STAGE DIESEL FILTER

GENERAL AGRICULTURAL MECHANICS

Unit E: Servicing Fuel and Air Systems

Topic 3: Servicing Air Cleaners and Crankcase Breathers

Suggested Procedures and Activities: An assortment of different types of air cleaners and a crankcase breather cap and element may be used as teaching aids during the class discussion.

1. The Purpose of Air Cleaners

The purpose of the air cleaner is to provide clean air to the engine. The farm tractor engine requires around 9,000 gallons of air to mix with each gallon of fuel that is burned. This would be equal to 165 55-gallon drums of air for each gallon of fuel. The air cleaner has the important job of furnishing clean air to prevent rapid engine wear. The air cleaner must remove dust and other foreign matter from the air. If this is not removed, the small abrasive particles will cause rapid wear of engine parts.

Transparencies Nos. 1 and 2

2. Types of Air Cleaners and Their Functions

The air cleaner must be so constructed as to let the clean air pass through and yet hold back the dust and foreign materials. There are several types of air cleaners which are designed to perform these functions.

a. The Oil Bath Air Cleaner - One type of air cleaner is made up of a container with a removable oil supply cap at the bottom, a screw element which fills most of the container, a center tube into which raw, dirty air enters, and an outlet tube which sends clean air to the carburetor.

When the dirty air reaches the bottom of the oil cap, it must change its travel and go back up through the screen. As the air passes the oiled screen the foreign particles will deposit themselves on the screen. As the oil droplets on the screen become heavy with foreign matter they will fall back into the oil cup, and new oil will be forced up into the screen with the rush of air.

b. The Dry Type Air Cleaner - There are several types of dry air cleaners in use on trucks, tractors, and other types of farm engines. Most of these cleaners have a heavy treated paper or other similar material which is folded accordion style to take out the foreign particles in the air. The folds furnish more filtering area and give the element more strength. As the air enters the cleaner it is directed in at a high speed, striking one side of a metal shield and forming a centrifugal action which causes dirt to be deposited in a dust cup at the bottom of the housing. In another type of dry cleaner the dirty air enters at a high speed past tilted fins. Again, a cyclone action causes dirt to be deposited in a dust cap. In both types partially clean air (80 to 90 percent dirt removed) passes through the chemically treated paper element. Usually a metal screen is used to protect the paper element in case of a backfire.

c. The Oil-Soaked Element Air Cleaner - The oil-soaked element air cleaner is used on some small tractors and some stationary engines and small engines. It is considered the standard type of air cleaner for a crankcase breather. This filter contains a fibrous element which is soaked in oil. As the dirty air passes through the oiled element, dirt particles are caught and held in the oily fiber. The three types include: crankcase breather cap as an oil filter cap, side mounted breather cap with element, and the standard type attached to the carburetor with removable element. A clogged breather will cause a buildup of pressure inside the engine which may force oil past the front and rear main bearing seals. The lack of ventilation may cause raw fuel, moisture, and gases to pass the pistons and enter the crankcase.

Regardless of the type of use of oil-soaked air cleaners, they do not have the cleaning capacity of the oil bath cleaner. They are not used as the main air cleaners on engines that require a large amount of clean air to operate, and they should not be used as a main source of cleaning on large engines in very dusty conditions.

Transparencies Nos. 2 and 3

3. Servicing Air Cleaners

a. Oil Bath Cleaner - The following steps should be observed when servicing the cleaner:

(1) Inspect the cup at least once each day when operating the engine in slightly dusty situations. If the sediment deposit is more than 1/4 inch or the oil has thickened, empty and clean the cup. It can be washed in diesel fuel or kerosene. Clean the air intake pipe if necessary. Always use fresh oil to refill cup.

(2) Consult operator's manual for oil recommendations and fill cup to required level. The same weight oil may be recommended as used in the engine crankcase.

(3) Reassemble the air cleaner and make sure all connections are secure when mounting it on the engine. Inspect the air duct between the air cleaner and carburetor on a gasoline engine. If replaced on a diesel engine inspect the air duct between the air cleaner and intake manifold.

(4) Inspect the pre-cleaner by removing and emptying the bowl. Under certain operating conditions (dusty plowing, harvesting) the inspection should be made daily.

b. Dry-Type Cleaner - Service the dry-type cleaner by using the following method:

(1) Clean the element by removing and tapping gently to remove dust. The element may be cleaned by using an air hose at low pressure (30 pounds per square inch). A nonsudsing detergent or element cleaner may be used to clean an oily or sooty element. It should be rinsed with clean water and let dry before reinstalling.

(2) Place a light inside the element and inspect for damage. Even a slight damage will cause it to be replaced. Inspect the filter element gasket and replace if necessary.

(3) Use a clean damp cloth and wipe inside cleaner body. Place the element in the proper position in the cleaner body. A fin type will require the fin end to be placed first. Check to see if the gasket is in place before drawing cup tight against body.

c. Oil-Soaked Cleaner - The proper way to clean this type of filter is as follows:

(1) When possible remove the element and wash it in a safe solvent such as a special solvent for this purpose or kerosene. Shake vigorously to throw off the solvent and let drain until it appears dry.

(2) Place the element in new oil long enough to completely soak

the fiber. Remove the element from the oil and let it drain for several minutes before reinstalling.

(3) Follow the same procedure for cleaning the permanently installed element found in the crankcase breather cap, except that the cap and metal fiber element are washed as a unit.

(4) For the carburetor connected oil-soaked filter, clean the air intake filter stack pipe and check all connections from this pipe to the filter and from the filter to the carburetor.

d. General information about the dry type air cleaner is as follows:

The air inlet system, other than the air filter, should also be carefully serviced. All hose connections should be checked to insure that no dirty air can get into the intake system. A gasket between the manifold and carburetor, if loose, can permit dirty air to enter the system. A worn throttle shaft can let in enough dirt to cause considerable damage to the engine. A well serviced air system, from intake to cylinder, will help prolong engine life by supplying good clean air and helping to prevent engine wear.

A heavy-duty type cleaner designed for use on tractor engines can have, in addition to the paper element, a set of bubble plates which will rapidly change the direction of air flow to help remove dust from the air. Some modern units are equipped with an automatic dust unloading valve. There are others with restriction indicators that glow when there is an air restriction in the filter.

References:

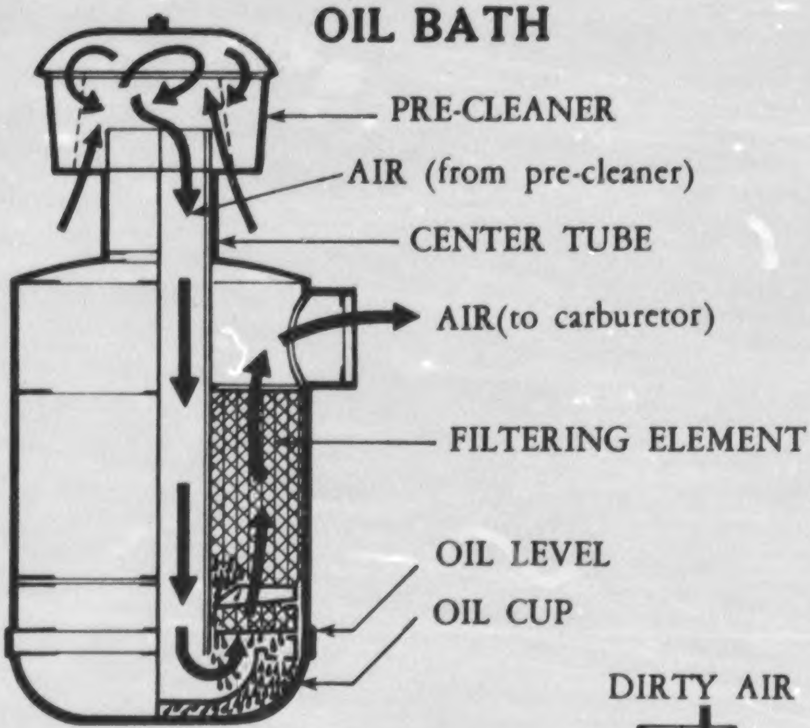
1. Promersberger, William J. and Others, Modern Farm Power, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1971

2. "Fundamentals of Machine Operation - Preventive Maintenance", Deere and Company, Moline, Illinois, 1973

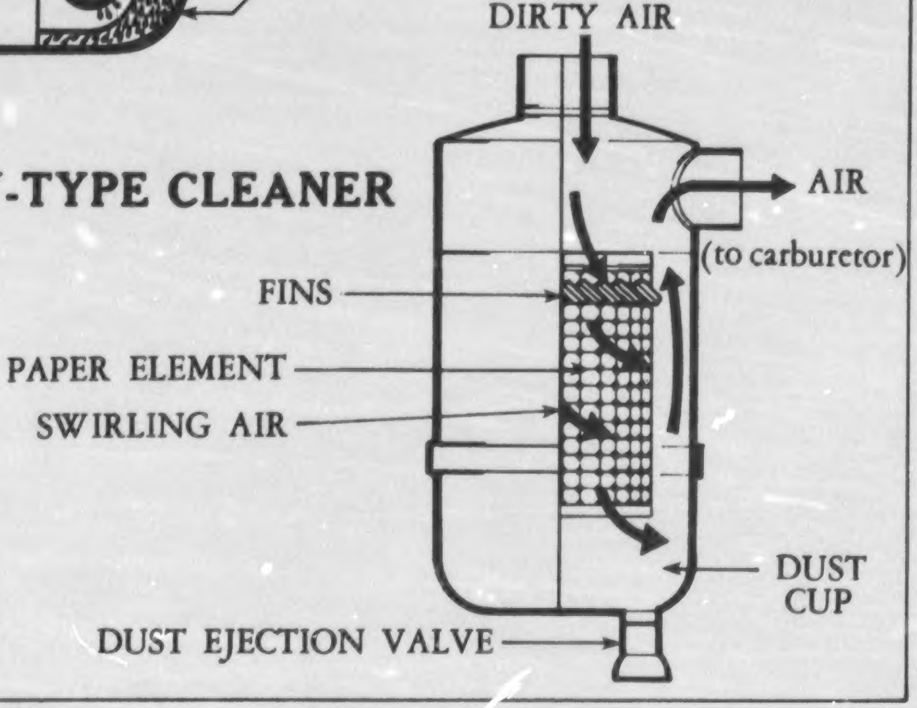
3. 'Tractor Maintenance - Principles and Procedures', American Association for Vocational Instructional Materials, Athens, Georgia, 1975

AIR CLEANER TYPES

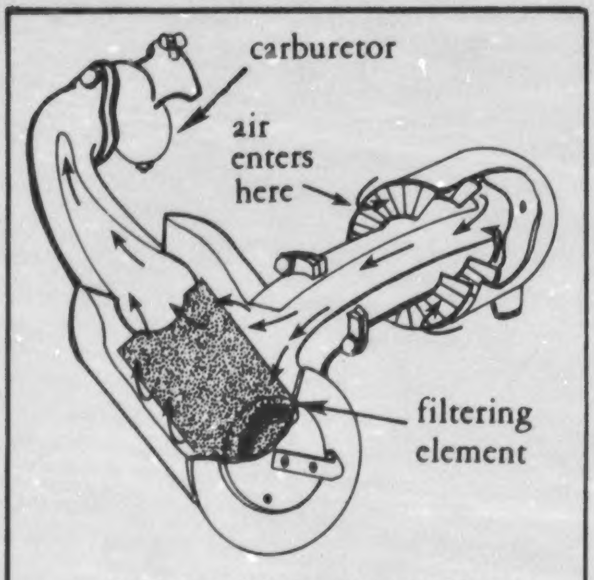
OIL BATH


PRE-CLEANER
AIR (from pre-cleaner)
CENTER TUBE
AIR(to carburetor)
FILTERING ELEMENT
OIL LEVEL
OIL CUP

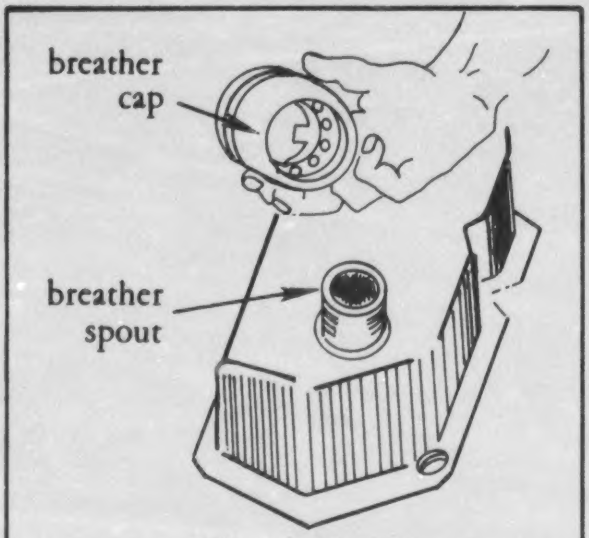
DRY-TYPE CLEANER


DIRTY AIR
AIR
(to carburetor)
FINS
PAPER ELEMENT
SWIRLING AIR
DUST CUP
DUST EJECTION VALVE

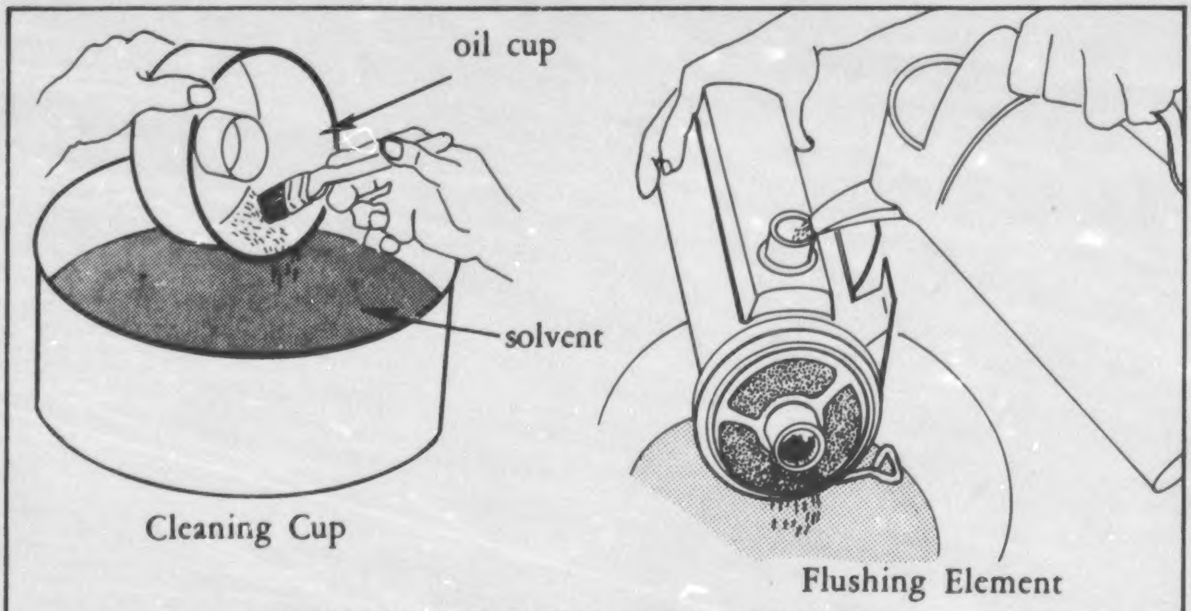
AIR CLEANERS & SERVICING


carburetor
air enters here
filtering element

OIL-SOAKED CLEANER


breather cap
breather spout

OIL-SOAKED CRANKCASE BREATHER

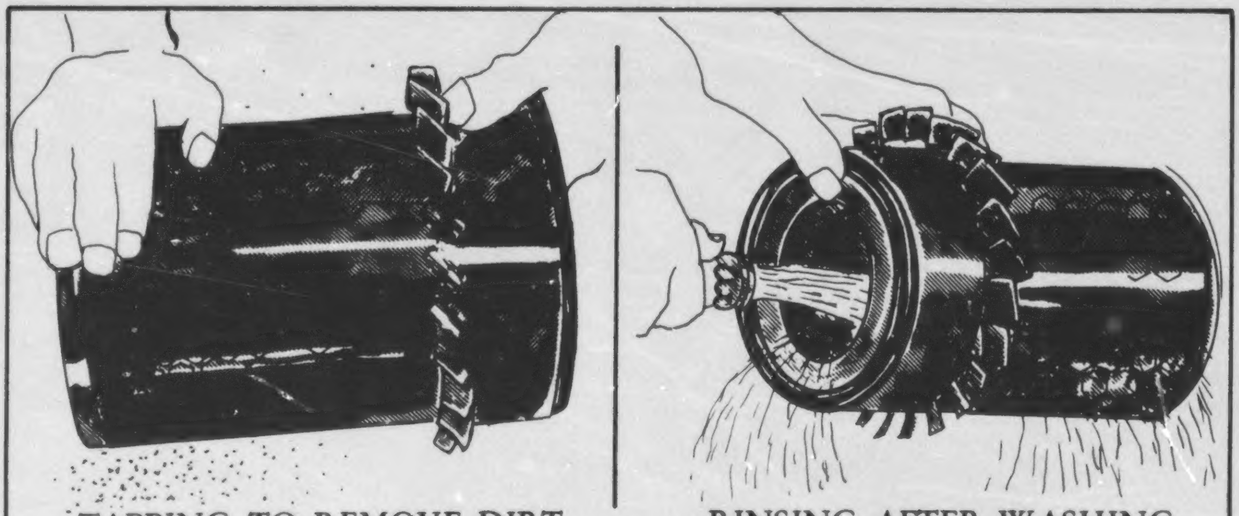

oil cup
solvent

Cleaning Cup

Flushing Element

CLEANING OIL-BATH CLEANER PARTS

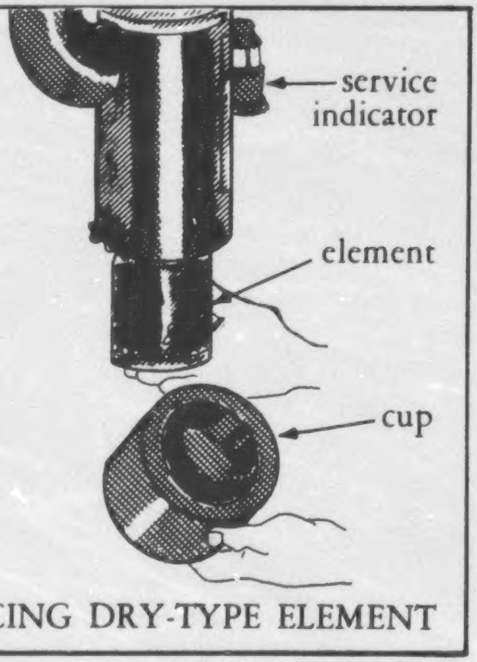
SERVICING AIR CLEANERS



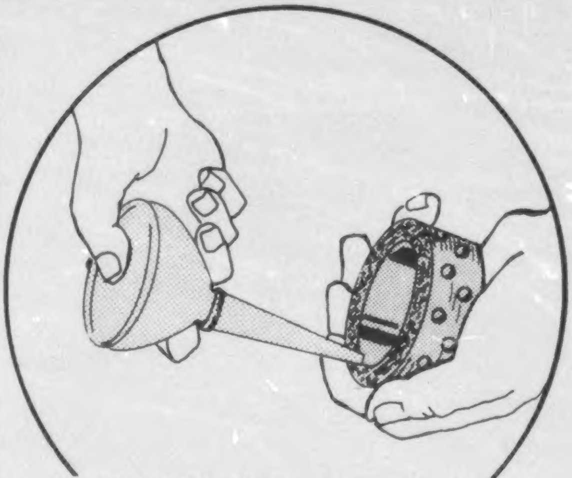
TAPPING TO REMOVE DIRT

RINSING AFTER WASHING

DRY-TYPE ELEMENT


service indicator
element
cup

REPLACING DRY-TYPE ELEMENT



LUBRICATING
OIL-SOAKED
SIDE MOUNTED
BREATHER ELEMENT

GENERAL AGRICULTURAL MECHANICS

Unit E: Servicing Fuel and Air Systems

Topic 4: Intake and Exhaust Manifolds and Pipes

Suggested Procedures and Activities: The use of the transparencies as a teaching aid may be helpful during the class discussion.

Transparency No. 1

1. Air Intake Systems

The intake system supplies the engine with the proper amount of clean air, at the proper temperature, and mixed with the proper amount of fuel for combustion.

There are two basic types of intake systems. These are the crankcase fuel system and the cylinder feed system.

The crankcase fuel system is used on some two-cycle engines to draw the air-fuel mixture into the crankcase where it is moved under pressure to the cylinder.

The cylinder feed system mixes the air and fuel together in the carburetor, then it is passed into the cylinder.

Transparency No. 1

2. Intake Manifolds

With gasoline engines, the air fuel mixture moves from the carburetor to the manifold and then to the intake valve. The gasoline intake manifold is usually very close to the exhaust manifold so as to utilize the exhaust heat to help vaporize the fuel.

On diesel engines, the intake manifold may be on the other side of the engine from the exhaust, because the fuel does not require heat outside the cylinder. Integral intake manifolds are made as a part of the cylinder head. An advantage of this is that the engine coolant surrounds the intake, giving a constant heating of the fuel. There are fewer points, offering less chance to leak.

A mixing valve and converter replace the carburetor on an L. P. gas engine. This gas is vaporized at normal temperature.

3. Manifold Heat Control Valve

The purpose of a manifold heat control valve is to direct exhaust gases onto some parts of the intake manifold when it is cold and away from the intake when it has been warmed up. The valve is controlled by a bimetallic coil spring which holds the valve open until the exhaust heat causes it to close. Care should be taken in checking the valve periodically to make sure it functions properly. The use of a special heat control lubricant will help keep the valve free.

Transparency No. 2

4. The Exhaust System

Exhaust systems have two main operations: (1) to collect exhaust gases and heat from engine, and (2) to carry these gases and heat away from the engine. The exhaust system consists of the exhaust valves, exhaust manifold, and the muffler.

a. The exhaust valves seal the cylinder during compression and fuel burning until most of the energy has been used up. They then open to clear the cylinder before the next charge of air and fuel is brought in.

b. Exhaust Manifold - The exhaust manifolds receive the burned gases from each cylinder and carry them away from the engine. Exhaust ports and the passages in the manifold are large to allow free passage of the exhaust gases. With the large passage ways there is free movement and better scavenging of the cylinders. If there are any exhaust gases left in the cylinder, it will reduce the amount of air-fuel mixture that can be received for the next charge. It is very important to clean the cylinder of burned gases and to keep the inner passages and surfaces of the manifold clean and free of carbon. This should be removed by use of a carbon solvent, by scraping, or a combination of both.

c. Mufflers - There are two common types of mufflers in use: the straight-through and the reverse-flow.

(1) The straight-through muffler has a perforated inlet pipe that is enclosed by an outer pipe which is about 3 times larger. The space between the pipes is usually filled with a heat resistant sound-absorbing material.

(2) Reverse-flow mufflers are made of a hollow chamber using short pieces of pipe and baffles to make the exhaust gases flow over a back and forth pattern before leaving the chamber.

Transparency No. 3

5. Superchargers

The purpose of the supercharger is to take atmospheric pressure air and compress it, and then pack it into the cylinders. The supercharger is an air pump located either behind or ahead of the carburetor. The power delivered by the engine is determined by the amount of air and fuel which can be packed into each cylinder. The supercharger helps to push the air into the cylinder. Pumping air into the cylinder helps to get exhaust gases out because of valve lag. This results in more efficient combustion.

There are three types of superchargers.

a. Root-Type Supercharger - These superchargers or blowers are positive displacement compressors. They are much like oil pumps in design. They operate by air entering the housing due to the rotation of the rotors. The air passes between the lobes on the rotors and the housing and is then forced out of the outlet of the unit. These blowers are driven either by belt, gear, or chain.

b. Centrifugal-Type Superchargers - These superchargers have a rotating impeller inside the housing. The normal speed is about 30 times engine speed. This is driven by a separate motor in some cases or it can use the engine exhaust gases to power the rotor. The centrifugal supercharger is less expensive, requires less maintenance, and does not make as much noise as the Root type.

c. Turbochargers - Turbochargers use a centrifugal compression, a housing, and a drive turbine. The compression and drive turbine are on the same shaft but in separate compartments of the housing. The turbocharger is not hooked mechanically to the engine. It is driven with the exhaust gases only, and discharges into the intake manifold. It may be lubricated and cooled by the engine systems.

Turbochargers for spark-ignition engines require mechanical controls if they are located ahead of the carburetor to help maintain the proper air-fuel mixture for all operating conditions.

When transporting a turbocharged machine on an open tractor, cover the exhaust outlet to prevent the intrusion of foreign matter or possible rotation of the turbochargers. Rotation without lubrication may cause damage to the bearings. Any time the engine is not in operation, the exhaust should be covered to protect the system. The turbocharger should be inspected daily for mounting connections and any leakage of oil. Make sure there are no air flow restrictions. Operate engine to see if there are any unusual noises. If so stop and inspect and find the trouble. Check for unusual vibrations. Excessive exhaust smoke can indicate incorrect fuel-air mixture. Service the air cleaner according to the operator's manual.

Testing the air intake system - If the air flow into the engine becomes restricted, there is more vacuum on the cylinders. This may cause oil to be sucked up around the pistons or valves and raise oil consumption. To check intake vacuum on diesel engines, warm up the engine, connect a vacuum gauge to the pipe fitting on the intake manifold, set engine speed at fast idle, and check the reading on gauge. A too high reading indicates there is a restriction in the intake system. Check the operator's manual for correct specifications.

If the vacuum reading is constantly low, it indicates a loss of power in all cylinders. Possible causes are late ignition, loss of compression at piston rings or valves, or bad valve timing. A leaky gasket at the carburetor can also cause a low reading. If the needle fluctuates continuously, a loss of power in one or more of the cylinders is indicated. This could be caused by a leaky cylinder head gasket, stuck piston rings, or defective ignition. Intermittent needle fluctuations are caused by a sticking valve or an ignition defect. Slow needle fluctuations are usually caused by the idle mixture at the carburetor being out of adjustment. A gradual drop of the gauge reading at idle speed indicates that there is a back pressure in the exhaust system.

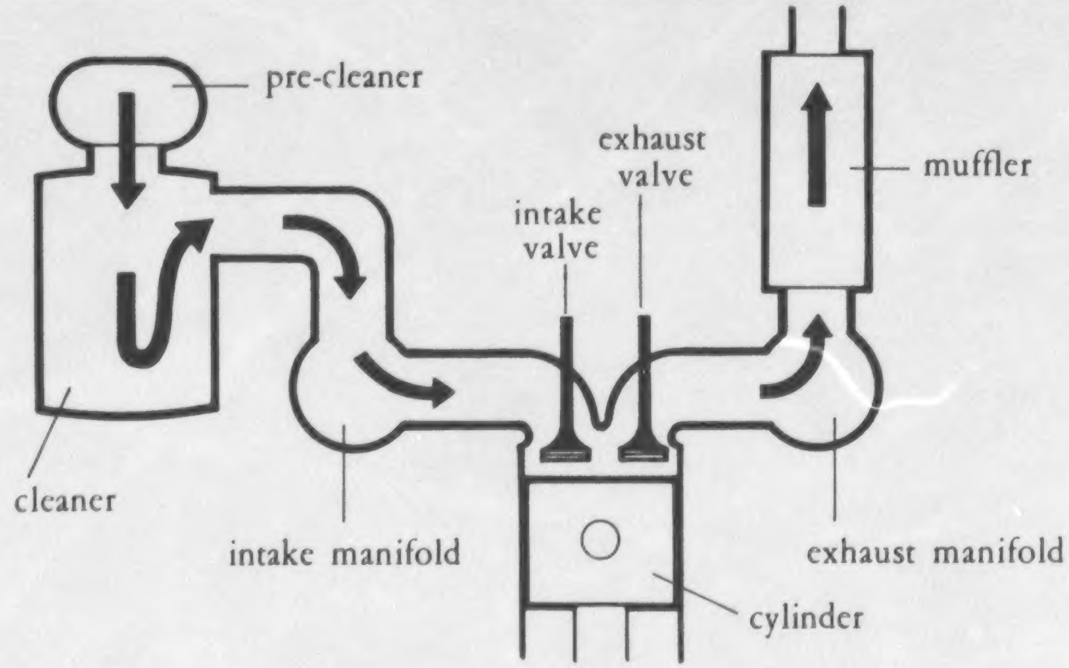
References:

1. Promersberger, William J., and Others, Modern Farm Power, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1971

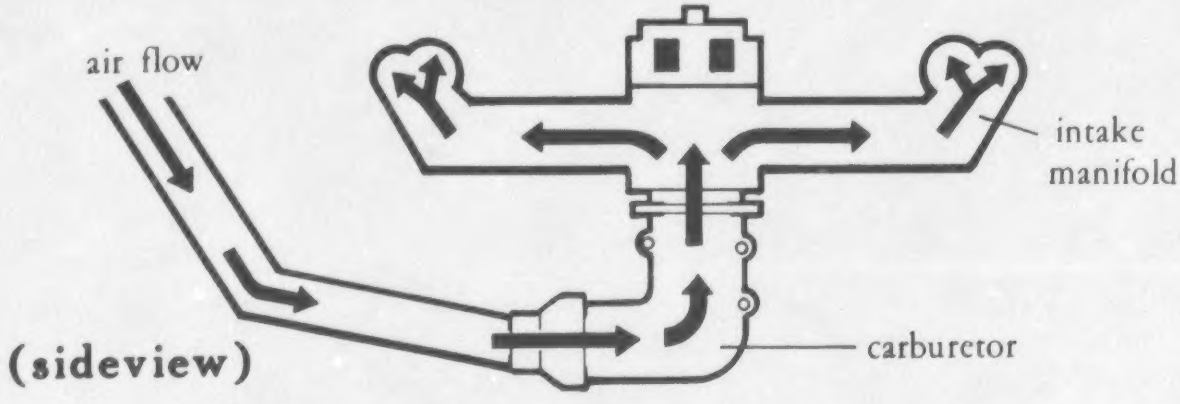
2. "Fundamentals of Service - Engines", Deere and Company, Moline, Illinois, 1972

3. "Fundamentals of Machine Operation - Preventive Maintenance", Deere and Company, Moline, Illinois, 1973

INTAKE & EXHAUST SYSTEMS

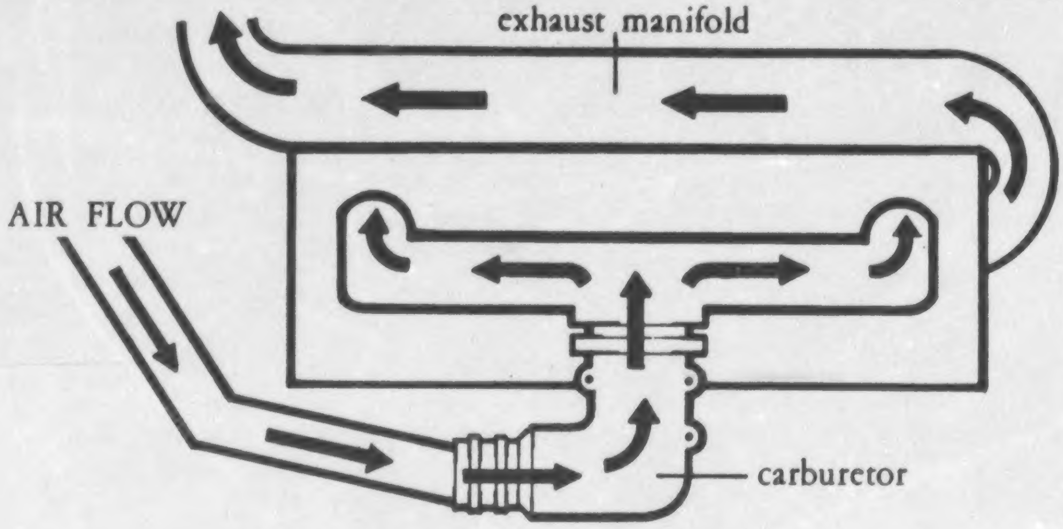

pre-cleaner
exhaust valve
muffler
intake valve
air cleaner
intake manifold
exhaust manifold
cylinder

CYLINDER FEED SYSTEM


air flow
intake manifold
(sideview)
carburetor

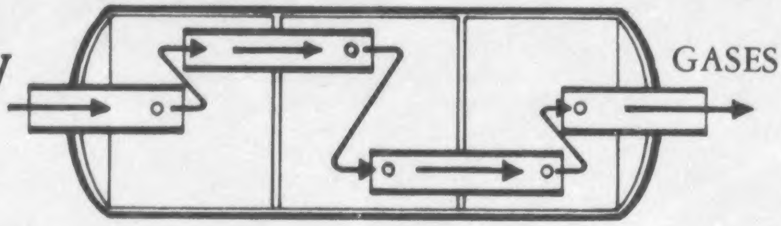
GASOLINE ENGINE INTAKE MANIFOLD

EXHAUST SYSTEMS

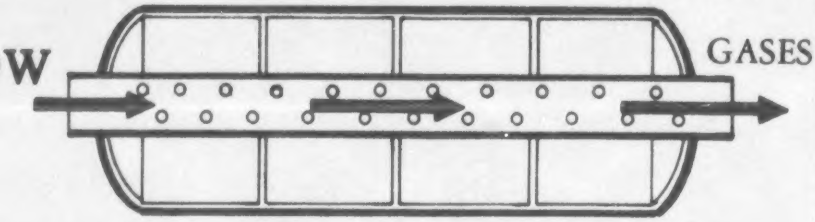

exhaust manifold
AIR FLOW
carburetor

EXHAUST MANIFOLD

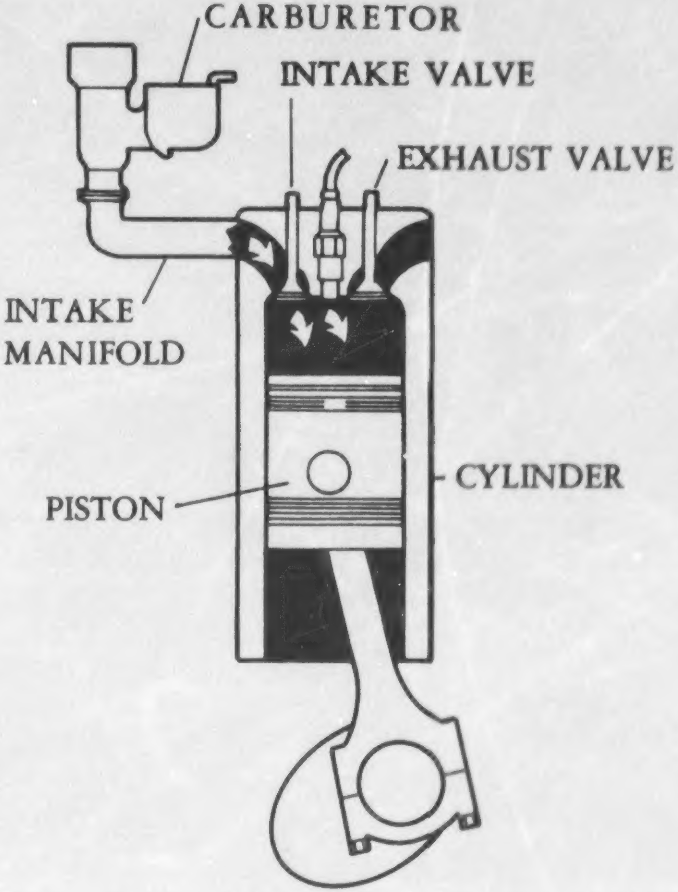
REVERSE FLOW MUFFLER



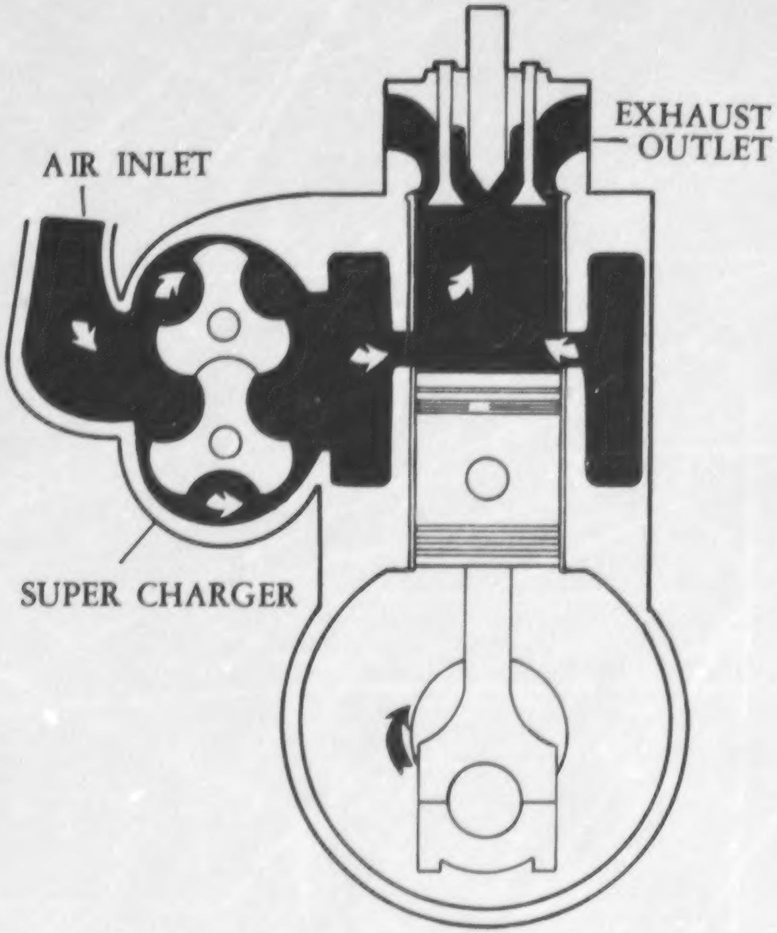
STRAIGHT FLOW MUFFLER



INTAKE & EXHAUST SYSTEMS


CARBURETOR
INTAKE VALVE
EXHAUST VALVE
INTAKE MANIFOLD
CYLINDER
PISTON

GASOLINE


EXHAUST OUTLET
AIR INLET
SUPER CHARGER

DIESEL

GENERAL AGRICULTURAL MECHANICS

Unit E: Servicing Fuel and Air Systems

Topic 5: Checking and Adjusting Gasoline and L. P. Gas Carburetors

Suggested Procedures and Activities: A gasoline and L. P. Gas carburetor (assembled and disassembled) will make excellent classroom teaching aids.

1. The Major Functions of the Gasoline and L. P. Gas Carburetors

The carburetor supplies the required amount of air and vaporized fuel to meet the various demands of engine speed and load. Two specific jobs of the carburetor are to atomize and vaporize liquid fuel and mix fuel and air in the proper ratio for a specified use.

a. Gasoline Carburetor - Engines cannot operate on liquid gasoline. The carburetor must atomize or vaporize fuel so it can be mixed with air. Atomizing fuel is done by adding liquid fuel to a stream of fast moving air as it passes through the carburetor on its way to the combustion chamber. The liquid tends to disintegrate upon contact with the gust of air coming through the carburetor. This divides the liquid into many tiny particles or droplets to allow for complete burning in the combustion chamber.

b. Liquid Petroleum (L. P. Gas) Carburetor - The L. P. Gas carburetor must mix air and fuel vapor in the proper ratio for various loads and the speed of the engine. L. P. Gas differs from gasoline in that it is already a vapor when it reaches the carburetor. Since L. P. Gas is already a vapor, the carburetor does not need a reservoir as do gasoline carburetors. Neither does it need a venturi to vaporize a liquid. An L. P. Gas carburetor sprays a vaporized fuel into a fast moving stream of air to produce an air-fuel mixture.

Transparencies Nos. 1 and 2

2. Carburetor Systems, Their Operation and Components

a. To simplify the explanation of the gasoline carburetor, four systems of the carburetor should be considered. This explanation pertains to a simple carburetor found on tractor and farm engines.

(1) The Fuel-Supply System - This system consists of a fuel float, fuel bowl, and bowl air vent. The float actually controls the level of fuel in the fuel bowl and the flow of fuel from the tank.

(2) The Idling System - This system consists of an idling jet, an idle discharge slot, and an idling well. It allows the engine to operate at a slow or idle speed on a no-load basis. The throttle valve is closed as the engine draws fuel from the idle well through the idle passage to the idle jet. Fuel is mixed with air from the opening of the air adjusting needle and the mixture is drawn into the engine through the idling slot. Acceleration opens the air tube causing air to pass the venturi and draw fuel from the discharge nozzle. This process starts the functioning of the load system.

(3) The Load System - The load system is made up of the venturi, main jet, metering well, and main jet adjusting screw. As the throttle plate opens past the idling position, an increased amount of air is pulled through the venturi. The load adjusting needle will allow the proper amount of fuel to be discharged from the main nozzle. For rapid acceleration there is extra fuel on hand in an accelerating well or metering well. This fuel is not called upon unless there is an increase in air velocity through the venturi which gives a sudden pull on the stream from the main nozzle.

(4) The Choke or Starting System - The choke system consists of a valve or plate located in the air intake opening of the carburetor. When the valve is closed, air is restricted to the engine. If the carburetor is equipped with an automatic choke, the thermostatic spring opens the choke plate as heat is applied. The proper fuel-air mixture is provided on a nonautomatic choke by opening and closing the choke valve manually. An opening called an overflow drain is found at the bottom of some carburetors. This opening, fitted with a filter, felt cover, or screen, allows excess fuel to drain off and prevents flooding of the carburetor when choked too much. Choking actually provides a rich mixture (more gasoline and less air) for starting a cold engine.

b. The L. P. Gas carburetor differs from the gasoline carburetor. It performs the same job of mixing air and fuel, but its components differ from the gasoline type. The different components are a result of the two fuels being in a different state. The L. P. Gas is a vapor when it reaches the carburetor, while gasoline is a liquid. This vapor must be mixed with the proper amount of air. The metering valve controls the vapor, and the throttle disk controls the air. Both of these components are operated by the engine throttle. A partial vacuum is created in the cylinder on the intake stroke which draws the mixture into the engine. A load adjusting screw gauges the fuel vapor reaching the spray bar. While the L. P. Gas carburetor has no venturi as does the gasoline carburetor, the spray bar affects air, already mentioned, in much the same way as the venturi in the gasoline carburetor. Incoming air to the carburetor hits the spray bar and is deflected. The deflected air is accelerated, creating a pressure drop. This pressure drop helps draw fuel vapor from the spray bar and blends it with air. Since L. P. Gas is vapor, there are no fuel float and fuel bowl, but other factors are similar to the gasoline carburetor.

Transparency No. 3

3. Classification of Carburetors According to Air Movement

There are three basic types of carburetors named for the direction that air flows through the carburetor to the manifold. All three types do the same job but in slightly different ways.

a. The natural draft carburetor uses a horizontal or cross-draft to supply air flow. It is used on engines that have little space on top or where a vaporized mixture is heated by coolant from the engine water jacket.

b. The updraft carburetor is usually located low on the side of the engine and is supplied fuel by gravity flow. The fuel is lifted into the intake manifold by high air velocities attained by using small passages in the carburetor throat and manifold.

c. The down draft carburetor is capable of handling larger volumes of fuel without an equally large volume of air. This type carburetor is used when high speeds and high power outputs are needed.

Transparencies Nos. 1 and 2

4. Adjusting Gasoline Carburetors

The gasoline carburetor should be kept in good condition and adjustment for economical and smooth operation of the engine. However, remember the ignition timing and engine speed adjustments affect and are affected by the carburetor settings. If one is changed then all should be checked. Most carburetors have three basic adjustments:

Idle Speed Adjustment
Idle Fuel Mixture Adjustment
Fuel-Load Adjustment

a. Preliminary Adjustments should be made by using the following steps:

(1) If the strainer screen in the carburetor is clogged, remove it and wash in a solvent. Reassemble before making air leak inspection.

(2) Check manifold connections and carburetor gaskets for air leaks. Place a few drops of light weight oil on areas that leaks may appear. Operate the engine and check to see if the oil is pulled into the manifold. Tighten the fittings if leaks are located or replace the gaskets.

b. Adjusting the idle speed:

(1) Warm up the engine to operating temperature.

(2) Set the idle-speed with the throttle closed. Increase the speed by turning clockwise and decrease the speed by turning counterclockwise. Consult the operator's manual for the recommended rpm. If the idling speed can be checked at the power take-off, according to the manual recommendations, use a portable tachometer and a watch to make the adjustment test or connect an electric tachometer to the ignition system. Some engines are equipped with a tachometer. It is not recommended that the idling speed be set by sound.

c. Adjusting the idle fuel mixture:

(1) Operate the engine until it is warm or until it reaches operating temperature with the speed lever in the idling position.

(2) To adjust the idle fuel mixture for smooth engine idling, turn the idle fuel mixture screw slowly clockwise or until the engine begins to stall; then turn the screw out (counterclockwise) slightly until the engine idles smoothly. This step either regulates the air or fuel which depends upon the type of carburetor being used.

(3) If it is necessary to reset the idle speed, follow the procedure recommended in 4. b. (2) It is not uncommon to set the idle speed and idle fuel mixture together.

(4) The idle fuel mixture may be set by turning the fuel mixture clockwise until the engine runs rough or shakes, then turning counterclockwise until it begins to shake again, counting the number of turns. Reverse to clockwise again and count one-half of the turns from one extreme to the other.

d. Adjusting the fuel-load mixture:

(1) The fuel-load mixture should be adjusted last for good fuel economy under load. A dynamometer and flow meter should be used if available with the machine in a stationary position. Operate the engine at a fast idle (full throttle) and turn full-load needle (main adjusting needle) clockwise until engine begins to lose power; then turn back (counterclockwise) until the engine picks up speed and begins to run smoothly. If black smoke appears, turn the screw clockwise slowly while maintaining the power and smoothness of operation.

(2) Check the engine under load by accelerating quickly. Backfiring means the mixture is too lean (too much air), and if black smoke appears, the mixture is too rich (too much gasoline). The engine should accelerate quickly without stalling.

The fuel float assembly is another source of adjustment in some situations. Check the height of the float when disassembling and assembling the gasoline carburetor. The correct height is usually given in the technical manual. Use a special float bending tool to adjust the height when necessary. If the float is badly warped or bent, replace it.

5. Adjusting L. P. Gas Carburetors

The L. P. Gas carburetor has basically the same adjustments as a gasoline carburetor. These adjustments are:

Idle Speed Adjustment
Idle Fuel Adjustment
Full-Load Fuel Adjustment

Adjustments may be made according to the following procedure:

(1) Warm up engine to operating temperature.

(2) Adjust idle speed at the stop screw. This adjustment should be made with throttle disk closed. Try to obtain the slowest engine idle without stalling the engine or causing rough idle. Consult a technical manual for the recommended rpm.

(3) The idle fuel mixture should be adjusted at the adjusting link. With the engine at slow idle, the link should be turned until the engine begins to stall; then it should be turned in the opposite direction until the engine idles smoothly.

(4) It may be necessary at this point to readjust the idle speed (step 2).

(5) The full-load fuel mixture should be adjusted for economy under load. The machine should be loaded while it is in a stationary position. A dynamometer should be used if available. The throttle disk should be wide open. Adjust by turning in the full-load fuel adjusting screw until the engine begins to lose power; then reverse the screw out until the engine picks up speed and runs smoothly.

(6) Check the operation of the governor mechanism or other speed controls. If they function erratically or overspeed, adjust them by following service manual procedures.

6. Carburetor Maintenance

Carburetor maintenance and upkeep are the keys to extended trouble free service. Periodic service of air breathers and air filter and service and replacement of fuel filters will extend the life of all carburetors. Following are a list of items which will help in extending the service of a carburetor.

a. Always service carburetors after a major overhaul or valve grinding.

b. Always service each year or at the beginning of the season in the case of seasonal equipment and machines.

c. Adjust the carburetor during engine tune-up or whenever the carburetor has been removed for service.

d. Adjust the carburetor any time the engine runs badly or needs speed adjustments.

There are repair kits made for practically all carburetors. Be sure that all parts used when repairing the carburetor are new. Again, any specific question about a particular carburetor should be referred to the technical or shop manual provided for that carburetor.

References:

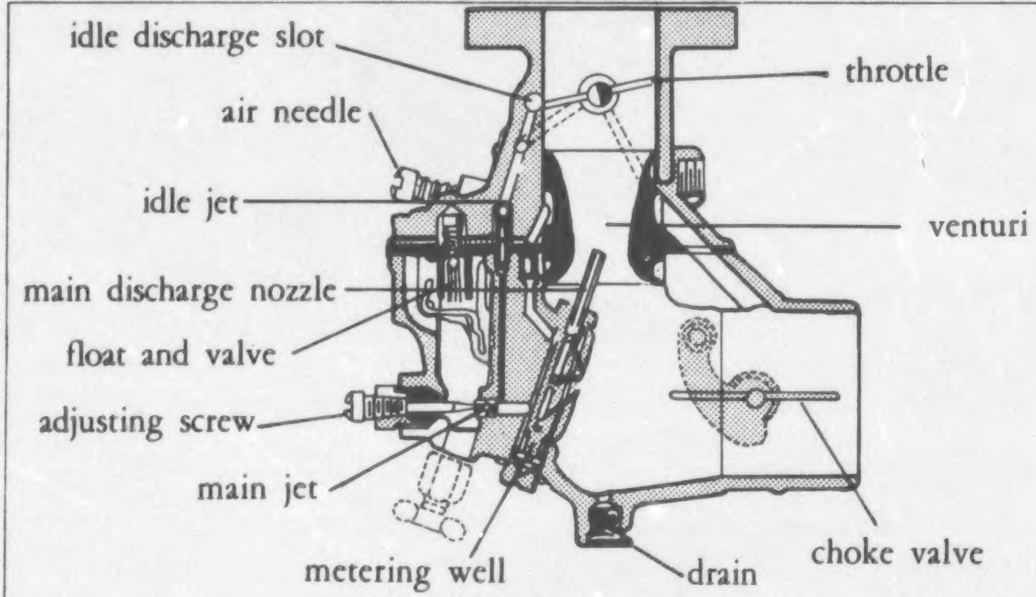
1. Promersberger, William J., and Others, Modern Farm Power, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1971

2. "Fundamentals of Service - Engines", Deere and Company, Moline, Illinois, 1972

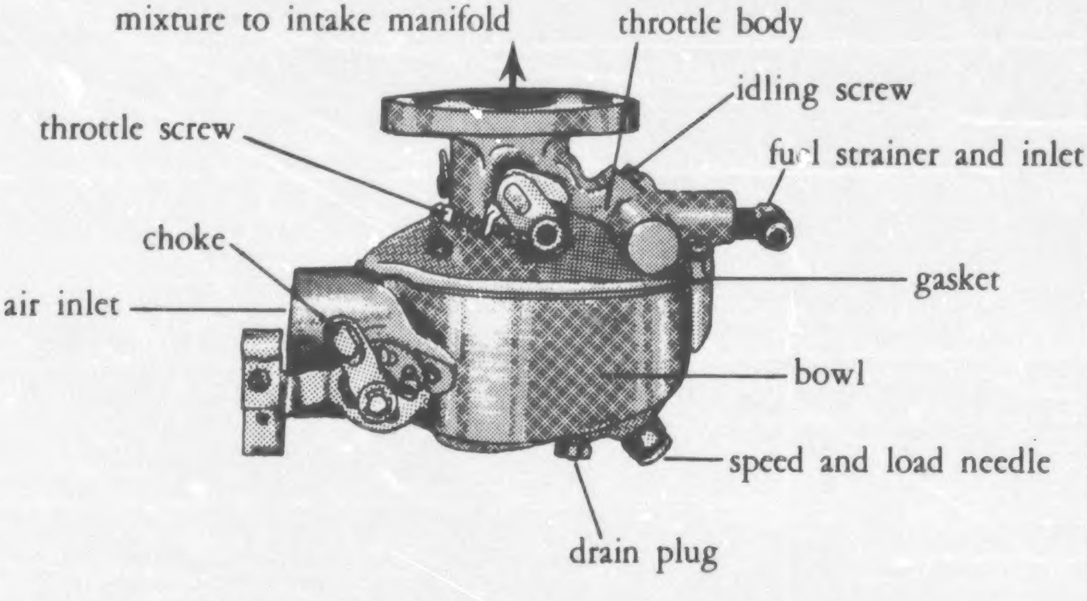
3. "Fundamentals of Machine Operation - Preventive Maintenance", Deere and Company, Moline, Illinois, 1973

4. "Tractor Maintenance, Principles and Procedures", American Association for Vocational Instructional Materials, Athens, Georgia, 1975

GASOLINE CARBURETOR PARTS

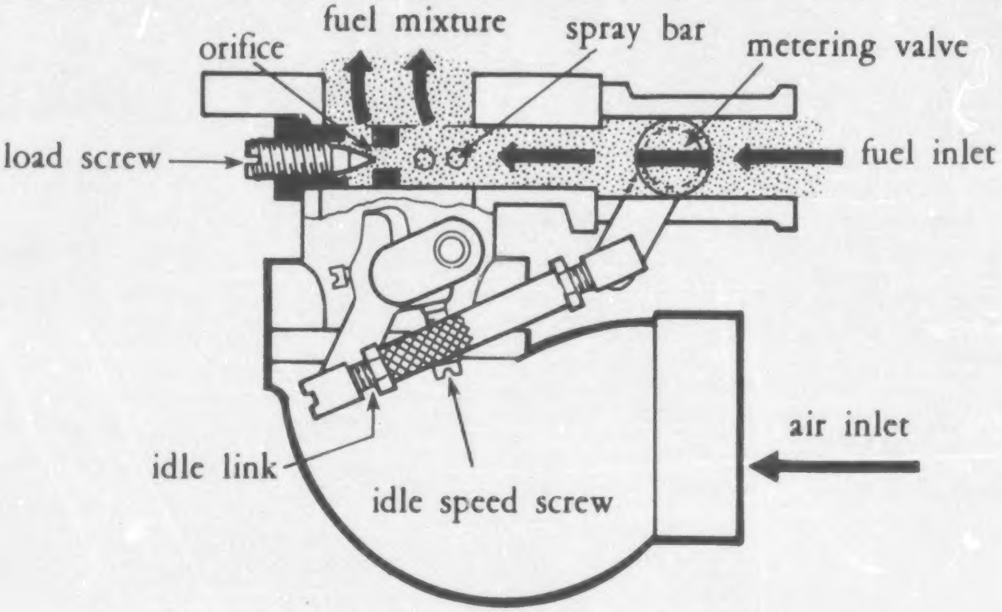

idle discharge slot
throttle
air needle
idle jet
venturi
main discharge nozzle
float and valve
adjusting screw
main jet
metering well
drain
choke valve

SINGLE VENTURI CARBURETOR

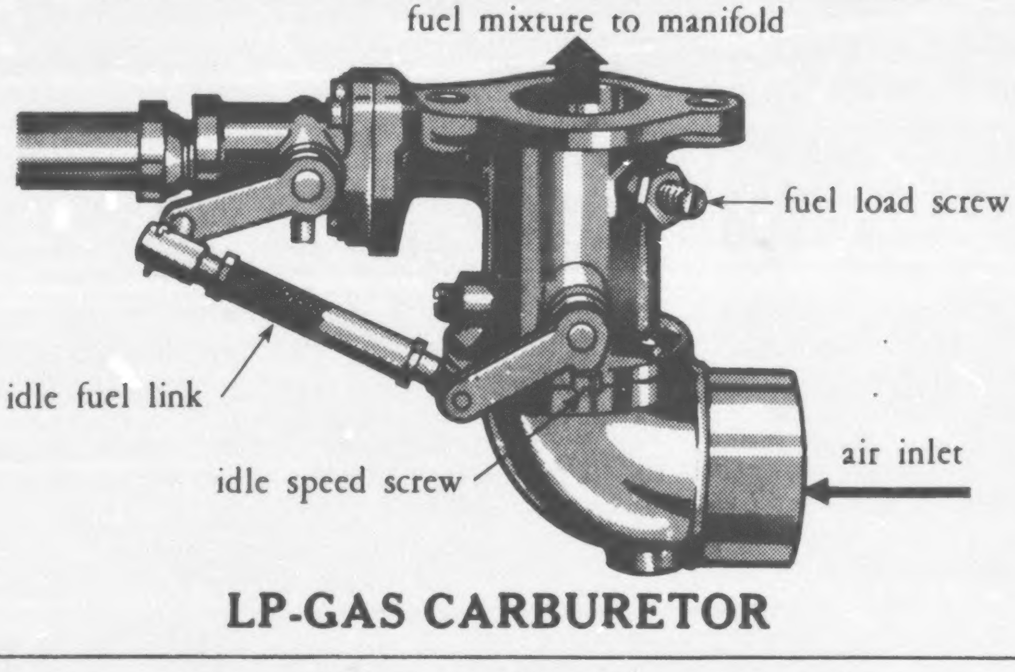

mixture to intake manifold
throttle body
idling screw
throttle screw
fuel strainer and inlet
choke
gasket
air inlet
bowl
speed and load needle
drain plug

SINGLE VENTURI CARBURETOR

LP-GAS CARBURETOR PARTS

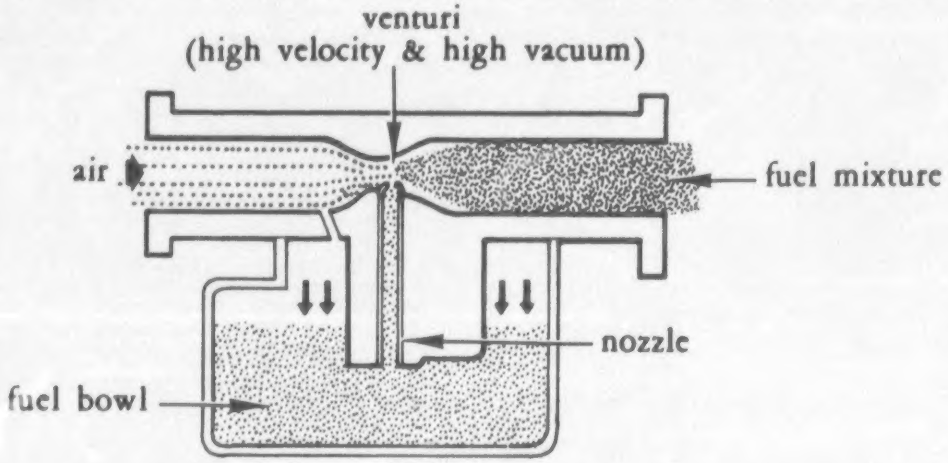

fuel mixture
orifice
spray bar
metering valve
load screw
fuel inlet
air inlet
idle link
idle speed screw

LP-GAS CARBURETOR

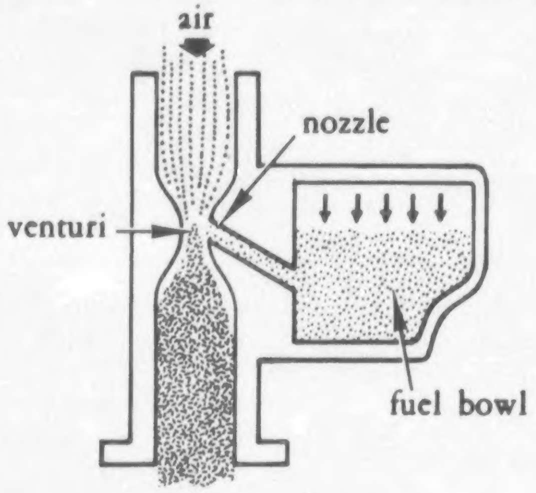

fuel mixture to manifold
fuel load screw
idle fuel link
idle speed screw
air inlet

LP-GAS CARBURETOR

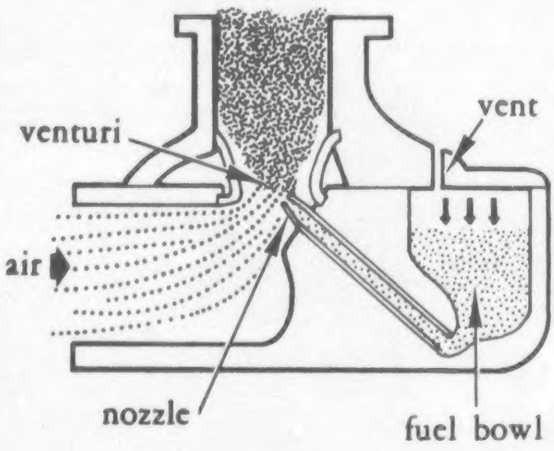
CARBURETOR DRAFTS


venturi
(high velocity & high vacuum)
air
fuel mixture
nozzle
fuel bowl

NATURAL DRAFT


air
nozzle
venturi
fuel bowl

DOWNDRAFT


vent
venturi
air
nozzle
fuel bowl

UPDRAFT

GENERAL AGRICULTURAL MECHANICS

Unit E: Servicing Fuel and Air Systems

Topic 6: Checking and Adjusting Governors

Suggested Procedures and Activities: Certain types of governors may be carried to the classroom and used as a teaching aid. Use the transparencies as visuals during the class discussion.

1. The Purpose of the Governor

The governor is a speed regulating device connected to the hand throttle on most farm machines. It should maintain a constant engine speed that is regulated by a throttle as the load changes. The governor will automatically adjust the flow of fuel to maintain a set speed. However, if set for a no load speed of 2200 rpm, it will not operate this fast under load; therefore, the engine speed is slightly reduced under partial loads, and as the load increases the engine speed decreases. If an engine has no speed control mechanism, it will continue to run faster or operate at increasing speed until it 'flies apart". Engines are designed to operate at certain speeds under varying loads, and the simplest way to regulate the speed is to regulate the amount of fuel entering the combustion chamber.

Transparencies Nos. 1 and 2

2. Operation of Engine Governors

   a. On spark ignition (gasoline and L. P. gas) engines the centrifugal type governors are usually driven by some rotating part of the engine such as the crankshaft or camshaft, and this type of governor is either flyball or flyweight operated. The main parts of spark-ignition governors consists of:

      Shaft
      Weights
      Sliding collar
      Spring
      Control rod
      Control rod turnbuckle

   b. The flyweights are pushed outward as the engine speeds up and the arms move a bearing on the shaft. The other arm has a spring attached in contact with the other end of the bearing. The speed control rod is attached to the spring and the throttle rod to the carburetor. This outward movement closes the throttle or butterfly valve. At this point a balance is developed between the flyweights and control spring to maintain a constant engine speed.

When extra load is put on the engine, the flyweights move in due to the centrifugal force being reduced on them. More pressure is placed on the governor arm from the drive plate, which permits spring tension to move the governor lever in the other direction, thus opening the throttle valve and allowing more air-fuel to enter the cylinders and increasing horsepower without increasing engine speed.

c. Automatic and vacuum governors are found on many farm machines. The governor is situated between the carburetor and intake manifold and is not connected to other parts of the engine. It is set to maintain a maximum operating speed. The cam-and-lever mechanism contains a housing and throttle valve that is spring controlled. As the valve closes there is a decrease in fuel flow. This action is caused by an increase in engine speed and suction. When speed and suction decrease, fuel flow is increased by the spring opening the throttle valve.

d. The governor on a diesel engine operates on about the same principles as governors on spark-ignition engines. Two common types of diesel governors are centrifugal mechanical and pneumatic. The operation of these two governors is as follows:

(1) Centrifugal Mechanical - This type of governor is built into the fuel injection pump, and the flyweights operate a rack that reglates the amount of fuel injected by the fuel pump. A hand lever is used to adjust the tension on the governor spring which controls the engine speed.

The governor is driven by a gear off the pump camshaft. Due to the fuel being supplied under pressure, the pump must put the same amount of fuel at the same pressure to each intake valve. This action is controlled by the rotation of the injector pump plungers.

As the shaft speed increases, the amount of fuel is increased, and as the shaft speed decreases, the amount of fuel is decreased. This governor functions at all engine speeds to give complete control of fuel supply to the cylinder.

(2) Pneumatic - A pneumatic governor system is used on some diesel engines to change the vacuum in the manifold. A throttle plate is located in the intake manifold,and it is controlled by a hand operated lever. This governor unit contains a diaphragm which is controlled by a spring. The diaphragm movement is in response to the manifold vacuum. A control rod transmits the motion to the pump plungers. Usually, a diesel engine takes in air into the cylinders and the vacuum remains constant in the manifold. A pneumatic governor changes the vacuum.

e. Another type of mechanical governor is the air vane governor. This is operated by the flow of air from the flywheel, which forces the vane to move. The vane is hooked directly to the throttle shaft. When the air forces the vane to move, the linkage opens the throttle valve. The other end of the throttle shaft is hooked to a spring which will tend to close the throttle valve. The more air from the flywheel, the more the throttle valve will open. With less speed, the spring will tend to close the throttle valve. Tension on the throttle spring is usually controlled by a hand operated lever.

3. Governor Adjustments

Some operator's manuals may suggest ways to adjust high no-load speed, whereas other manuals may suggest that the governor by adjusted by only a trained technician.

Governors are properly set to control engine speed at various loads on all new engines. However, a governor could function improperly if the parts become worn, begin to bind, or the spring loses its tension. Even though there is a maximum speed stop adjustment on the flyball or flyweight spark ignition type and a bumper spring adjustment screw on the diesel pneumatic type governors, adjustments should be made by a skilled technician who has speed indication equipment.

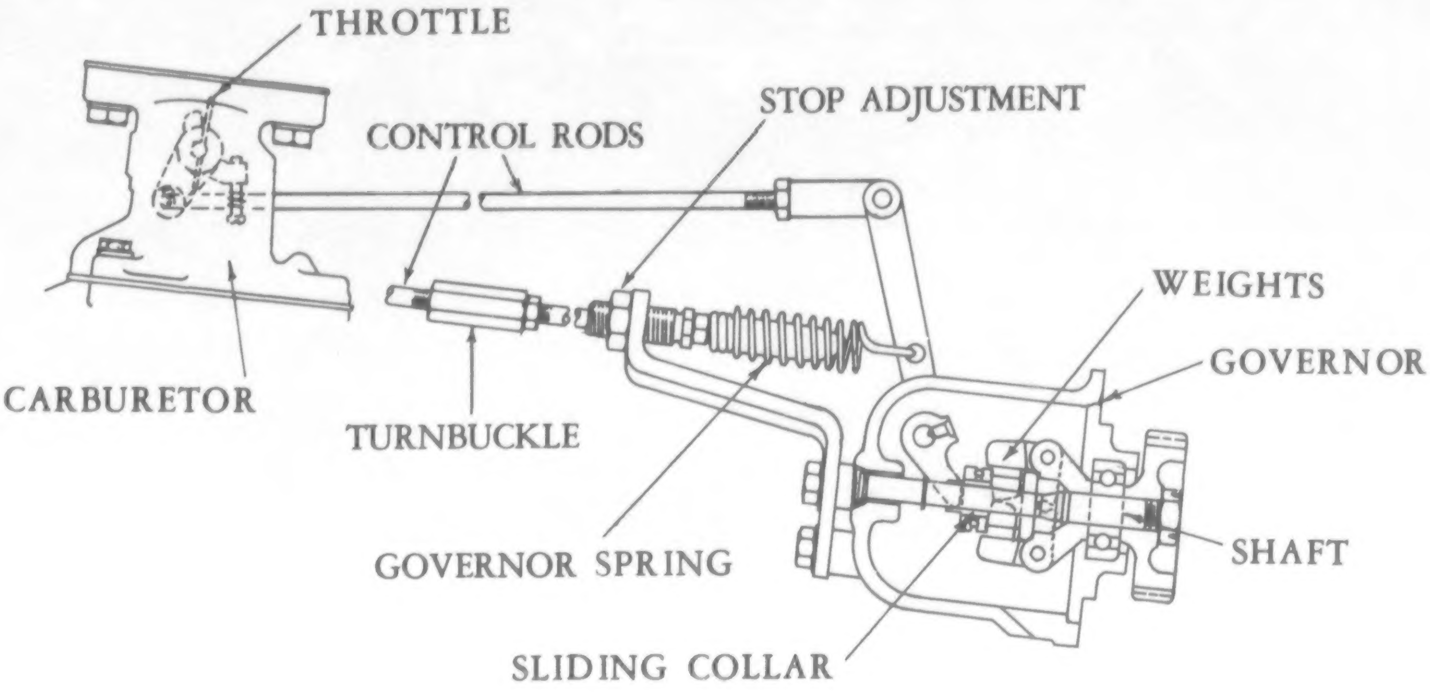
References:

1. Promersberger, William J., and Others, Modern Farm Power, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1971

2. "Fundamentals of Machine Operation - Preventive Maintenance", Deere and Company, Moline, Illinois, 1973

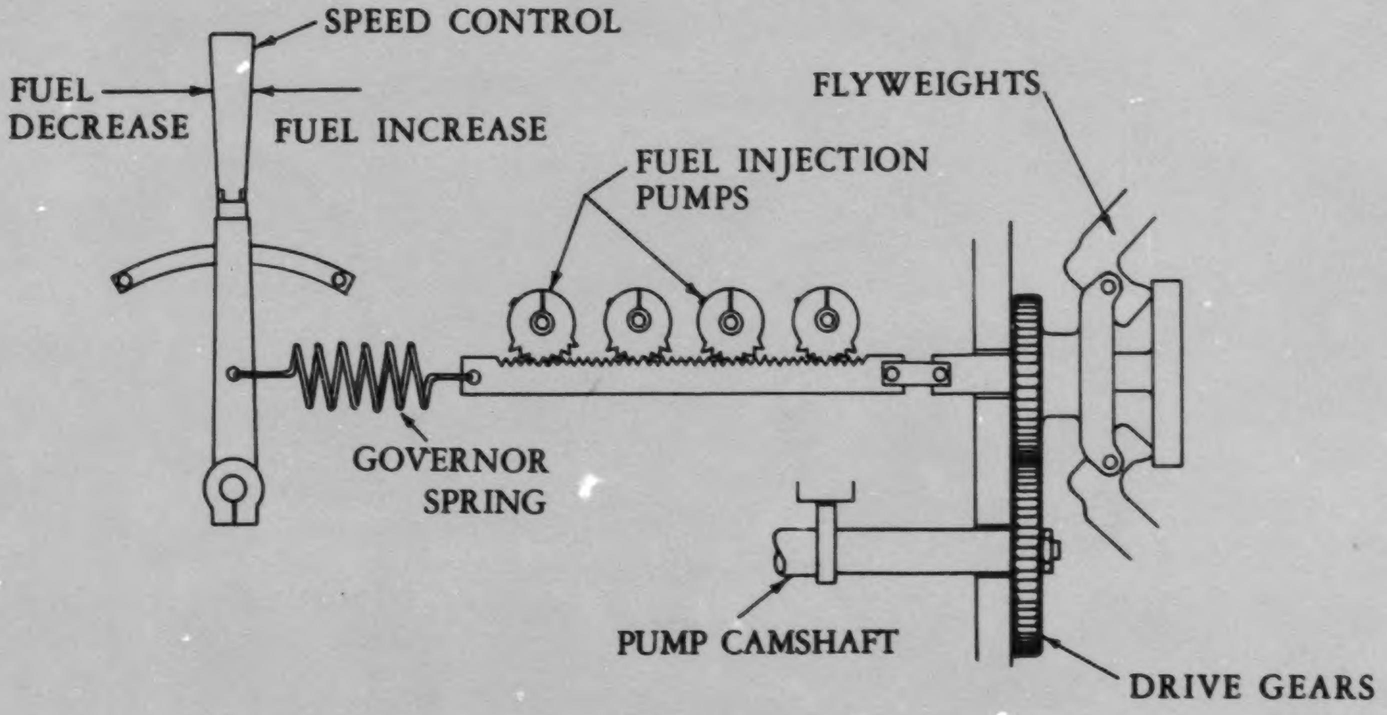
3. "Tractor Maintenance, Principles and Procedures", American Association for Vocational Instructional Materials, Athens, Georgia, 1975

GOVERNORS


THROTTLE
STOP ADJUSTMENT
CONTROL RODS
WEIGHTS
GOVERNOR
CARBURETOR
TURNBUCKLE
SHAFT
GOVERNOR SPRING
SLIDING COLLAR

FLYBALL GOVERNOR ASSEMBLY (GASOLINE)

GOVERNORS


SPEED CONTROL
FUEL DECREASE
FUEL INCREASE
FLYWEIGHTS
FUEL INJECTION PUMPS
GOVERNOR SPRING
PUMP CAMSHAFT
DRIVE GEARS

FLYWEIGHT GOVERNOR ASSEMBLY (DIESEL)

GENERAL AGRICULTURAL MECHANICS

Unit E: Servicing Fuel and Air Systems

Topic 7: Checking and Adjusting Diesel Injector Pumps and Nozzles

Suggested Procedures and Activities: After the class discussion and review of transparencies, the students may review the main parts of an injector pump and nozzles.

Transparencies Nos. 1 and 2

1. Principles of Operation

   a. The diesel engine fuel system is different from gasoline and L. P. gas engines in that air alone is drawn into the cylinder by the intake stroke or is forced in by a blower system. An atomized and pressurized charge of fuel is injected into the cylinder and is burned as it is mixed with hot compressed air; therefore, no electrical spark is used to ignite the fuel. There is always a full cylinder of air taken in, but the amount of fuel varies according to the speed of the engine. The major component parts of the diesel fuel system are: the fuel tank to store the fuel, fuel transfer pump to push fuel through the filters to the injection pump, fuel filters to clean the fuel, injection pump to time, measure, and deliver fuel under pressure to injectors, and injection nozzles which atomize and spray the fuel into the cylinders.

   b. There are more than one type of combustion chamber in a diesel engine. These different type chambers are known as: open or direct injection, separate or turbulence, precombustion, air cell or auxiliary, and energy cell. In all except the open chamber cylinder the burning fuel begins in a small combustion space and extends into the large area over the piston. The special cylinder wall or piston design helps mix the air and fuel for burning in each type of chamber. Combustion is caused by raising the compressed air temperature between 1000° and 1100° F.

   c. Starting a diesel engine is no problem except maybe during extremely cold weather. Starting aids for these unusual conditions are:

      (1) An electrical glow plug located in the small turbulence chamber with the injection nozzle is used to ignite the air-fuel mixture. Once enough heat is generated in the chamber to ignite the fuel mixture, the aid of the glow plug is no longer used.

(2) Another aid is the use of a volatile vaporized liquid (ether). Usually there is enough heat in the combustion chamber to ignite the vaporized liquid, and as soon as normal combustion is realized the liquid is no longer needed.

2. Major Types of Injection Pumps

There are three major types of injection systems.

a. The Common Rail - This is an older system which keeps constant fuel pressure in a header which serves all of the nozzles. The pump is mechanically activated by revolving cams. The quantity of injected fuel depends on how long the valve stays open.

b. The Accumulator System - The quantity of fuel to be injected can be varied regardless of the pump speed by using an adjustable spring or a hydraulic accumulator to control the fuel pressure. A cam driven pump sends fuel through the nozzle check valve into the accumulator as well as through the spill duct into the spring chamber. When the pump is full it will start to bypass fuel, and the nozzle check valve will close. Fuel which is in the spring chamber is then vented back through the spill duct to the pump. The fuel in the accumulator passes through the discharge duct to the nozzle.

c. Jerk Pump System - This system is used on the latest models of machines. The pump regulates the intervals of injection, meters the fuel, and causes the fuel to pass through the nozzles under high pressure. The duration of fuel flow and the quantity of fuel injected in the combustion chambers can be better controlled by the jerk pump system. These pumps operate on the cam and plunger principle. The revolving cam moves the plunger up and down to pump fuel out to the nozzles. The shape of the cam will control three things: (a) the quantity of fuel, by how far the plunger travels, (b) timing - when the plunger movement takes place, and (c) the rate of delivery, by how fast the plunger moves.

The injection pump is a precision piece of machinery and should not be disassembled by the operator. If the pump is giving trouble, it should be taken to an authorized pump repair center where it can be properly cleaned, assembled, and calibrated to the specifications of the manufacturer. Then it should be reinstalled on the machine by a qualified diesel mechanic so it will give trouble free operation. Most farm and industrial machines use a distributor or in-line injection pump. The distributor type pump distributes fuel to all cylinders, and the in-line pump system is made up of an individual pump for each cylinder.

Transparency No. 2

3. Injection Nozzles

The purpose of the injection nozzle is to atomize the fuel to give better combustion. It must spread out the fuel spray so it can mix fully with the air charge, and in multi-cylinder engines all nozzles must inject the fuel equally for smooth power. Types of nozzles are:

a. Inward Opening Nozzles

Differential pressure nozzles are operated hydraulically. When the fuel pressure in the nozzle reaches a pre-set level, the nozzle valve will open against a spring and inject fuel. As the fuel pressure drops, the spring will close the valve. The spring tension can be adjusted to set the opening pressure of the valve.

Hole-type nozzles have some extra features. The hole size and number of holes can be varied so as to get the best spray pattern. These nozzles are best used in engines with open combustion chambers.

Pintle-type nozzles use a tapered type valve which seats in an orifice in the valve body. The nozzle produces a hollow spray and is not used as much as the hole type.

Pintaux-type nozzles are a variation of the pintle nozzle. A hole is added to spray fuel at an angle during the low engine speed. This hole is angled toward the hottest part of the combustion chamber and will help also as an aid in starting.

b. Outward Opening Nozzles

The poppet-type nozzle has a fine vapor spray but with the low fuel pressure has too little penetration for many diesels.

Pintle-type outward opening nozzles are opened by fuel pressure, and the tapered head with extra shoulder acts rapidly to prevent dribbling of fuel. This is a simple nozzle but very light weight.

Multi-orifice nozzles are just a variation of the pintle type. When the valve opens the fuel sprays out of a ring of holes instead of out past the pintle and out the head.

c. The Parts of a Nozzle and Nozzle Operation

(1) Nozzle Parts -
- (a) Nozzle body
- (b) Nozzle valve
- (c) Spray tip
- (d) Locating clamp
- (e) Fuel inlet
- (f) Fuel leak-off
- (g) Pressure adjusting screw
- (h) Pressure spring
- (i) Lift adjusting screw
- (j) Seal

(2) Operation of a Nozzle -
- (a) The two moving parts in a nozzle are the spring and the valve. This valve movement is controlled by the lift adjusting screw, and the opening pressure of the nozzle is controlled by the pressure adjusting screw.
- (b) High pressure fuel from the pump enters the valve inlet and forces the nozzle valve from its seat. At this point fuel is injected into the cylinder, and immediately the pressure drops causing the spring to close the valve.

d. Servicing Injection Nozzles

Injection nozzles are precision made and operate under extreme heat and pressure, so they sometimes fail. The most common cause of failure is dirt clogging the openings or passages. This problem can be resolved by proper cleaning of the nozzle. Some cleaning steps are as follows:

(1) Soak the entire assembly in a clean solvent or suitable fuel after discarding the outer seals.

(2) Clean the nozzle body and spray tip with a wire brush. Do not use emery cloth or a steel wire wheel brush. Such cleaning material may damage the nozzle tips.

A detailed explanation for testing a nozzle for valve leakage, opening pressure, chatter, and spray pattern is given in Unit B, Topic 3, Selecting and Using Testing Equipment.

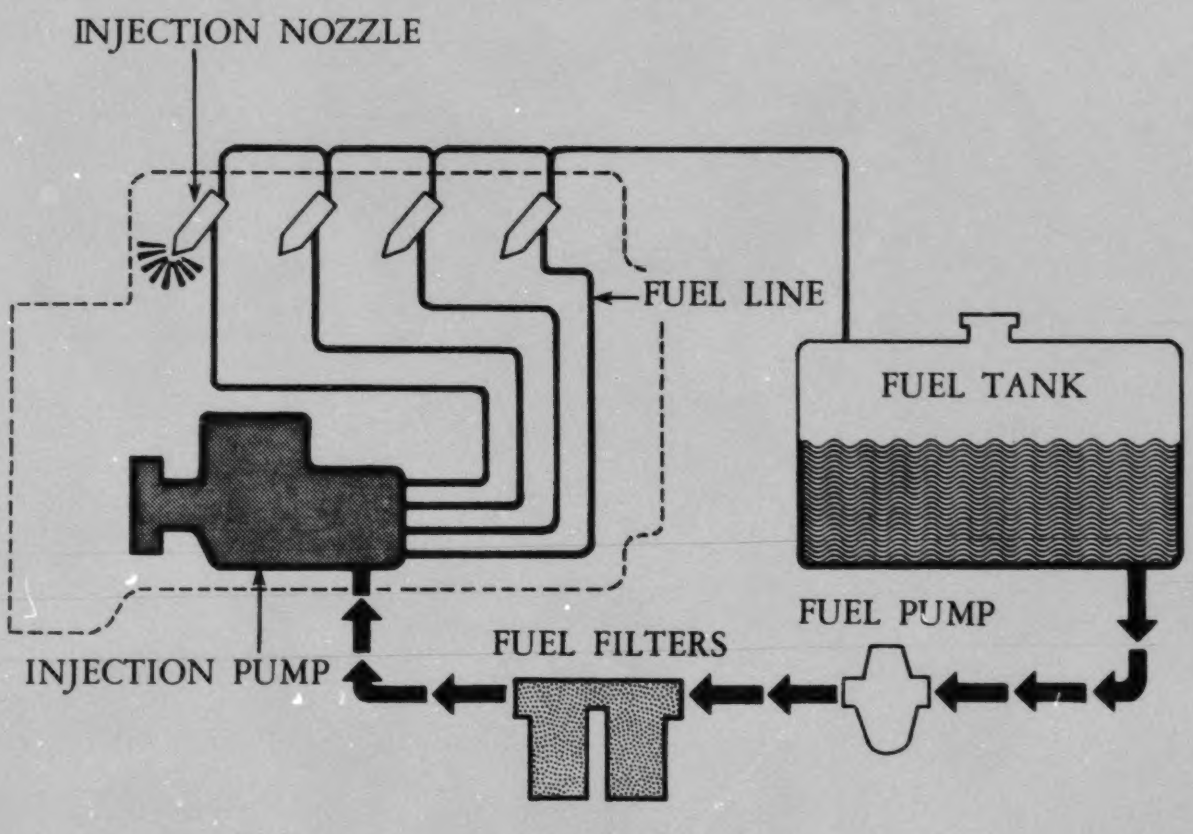
References:

1. Toboldt, William K., Diesel Fundamentals, Service, Repair, The Goodheart-Willcox Company, Inc., South Holland, Illinois, 1973

2. "Fundamentals of Service - Engines", Deere and Company, Moline, Illinois, 1972

3. "Fundamentals of Machine Operation - Preventive Maintenance", Deere and Company, Moline, Illinois, 1973

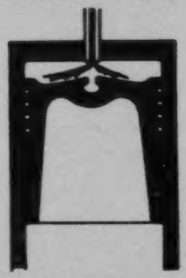
PRINCIPLES OF OPERATION


INJECTION NOZZLE
FUEL LINE
FUEL TANK
FUEL PUMP
FUEL FILTERS
INJECTION PUMP

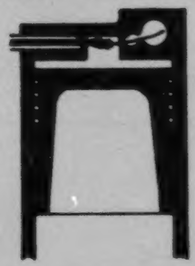
DIESEL FUEL SUPPLY SYSTEM

PRINCIPLES OF OPERATION

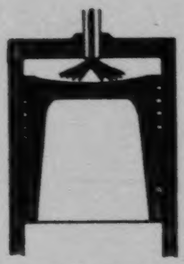
COMBUSTION CHAMBER DESIGNS



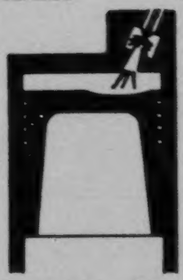
AIR CELL OR
AUXILIARY CHAMBER



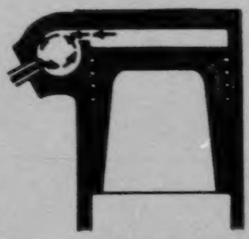
ENERGY CELL OR
AUXILIARY CHAMBER



OPEN CHAMBER
OR DIRECT
INJECTION

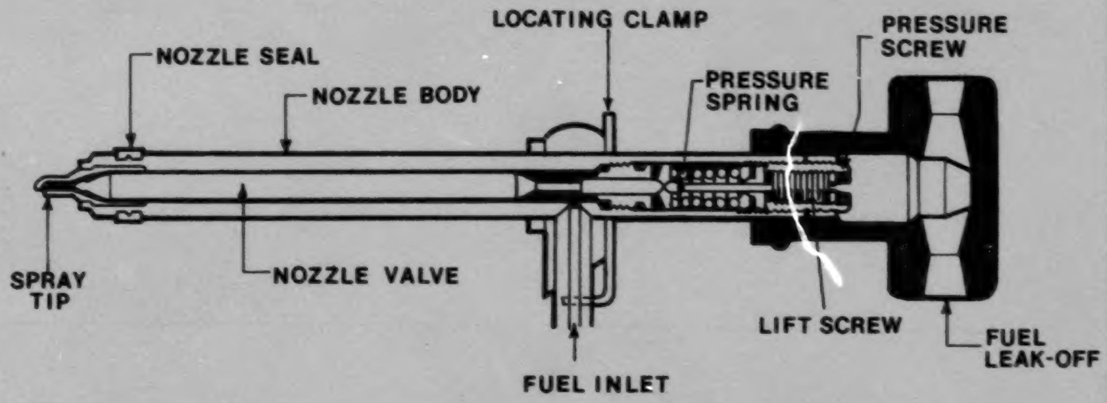


PRECOMBUSTION
CHAMBER



SEPARATE OR
TURBULENCE
CHAMBERS

INJECTION NOZZLE


LOCATING CLAMP
PRESSURE SCREW
NOZZLE SEAL
PRESSURE SPRING
NOZZLE BODY
SPRAY TIP
NOZZLE VALVE
LIFT SCREW
FUEL LEAK-OFF
FUEL INLET

GENERAL AGRICULTURAL MECHANICS

Unit F: Lubricating Power Units

Topic 1: Selecting and Using Engine Lubricants and Filters

Suggested Procedures and Activities: Samples of oils may be helpful as teaching aids during the class discussion. A display of samples of used and unused oils will make excellent teaching aids.

1. Using Quality Engine Lubricants

In order to receive the best possible performance from a machine, it is important to use lubricants of the highest quality. It is also advisable to use oil that manufacturers recommend and specify for the equipment used. Oils are recommended for their ability to perform under specific conditions. They have classifications and groupings which have been set up to determine their use. These classifications are oil viscosity (grade) and oil type (quality).

Transparency No. 1

a. Oil viscosity is a term used to measure the fluidity, thickness, or resistance to flow at a given temperature. In a viscosity test, a measured amount of oil is brought to a specified temperature (usually 100 degrees F. or 210 degrees F.). The length of time, in seconds, required for a specified amount of oil to flow through a small orifice in an instrument, such as a Saybolt or Kinematic Viscometer, is recorded. The grade is then determined by comparing the time to a standard set up by the Society of Automotive Engineers (SAE).

Oils vary in viscosity or thickness as temperatures change, becoming more fluid or thinner as temperature increases and less fluid as temperatures decrease. The temperature effect on viscosity is not the same for all oils. This fact should be known so the proper oil can be used for a specific job.

Some oils can be compounded to behave as light (thin) oils at cold temperatures and as heavier (thicker) oils at high temperatures. These oils are called multi-grade or multi-viscosity oils and are assigned numbers such as 10W-30, 10W-40, etc. When recommended, a multi-viscosity oil can replace as many as four or five single-grade oils.

These oils can give protection at both high and low temperatures; however, multi-viscosity oils are primarily intended for use during seasons in which periods of both extreme heat and extreme cold occur. They are generally not recommended for use in warm weather.

SAE viscosity numbers are used to indicate a permissible range or limit of viscosity at specified temperatures. These numbers are found somewhere on the container. No attempt is made to define the oil's quality, additive content, suitability for specified service conditions, or performance value. This indicates that the SAE viscosity should not be the only factor considered when selecting an oil.

b. In addition to getting the proper oil viscosity, it is just as important to select the proper type or quality of oil to fit the conditions under which a piece of equipment operates.

With the introduction of higher compression engines which work under more severe conditions, it was evident that there is a need for a way of matching oil quality with the fuel being used and the severity of operating conditions. As a result, a method of classifying oils by types was developed by the American Petroleum Institute. The classification of the API has recently changed, and the previous method has been phased out and replaced by the following classification. The following charts also contain SAE letter designation and an engine oil description by the American Society for Testing Materials (ASTM). Charts I & II, pages 7 and 8.

Transparency No. 2

c. To meet the needs created by the various operating conditions that are described in oil classifications, oil companies must add certain chemical compounds that are not present in petroleum oil but are added to prevent the formation of engine deposits, retard wear of certain engine parts, and aid in cleansing the engine.

(1) Oxidation and corrosion inhibitors reduce the breakdown of oil at high temperatures and the presence of certain metals such as copper and iron. When oil oxidizes and the corrosion process begins, oil reaches a point where it produces undesirable varnishes and sludges and corrosive acid. Varnishes and sludge cause oil to increase in viscosity. This results in shortened engine life.

(2) Detergent-dispersants are another group of additives. It was learned that organic soaps added to oils give a cleaning action that results in cleaner engine operation. The action of a detergent-dispersant prevents sludge from settling out of the oil and accumulating on metal surfaces of the engine. The sludge or dirt particles are washed from the surfaces and kept suspended in the oil. These particles are not caught in the filter but are held in suspension until the oil is drained or until the detergent-dispersant properties lose their strength and allow the particles to settle on engine parts.

(3) Other oil additives are:

(a) Anti-foam Agents - Foam inhibitor additives help prevent air bubbles which would restrict lubrication. This speeds up the rate at which air bubbles break up.
(b) Anti-rust Additives - These prevent rusting of metal parts during storage periods and neutralize acids in the engine. They cling to metal surface and build up a protective coating, which repels moisture.

2. Changing the Engine Lubrication

a. To receive full benefit from the qualities made into oil, it is necessary to drain oil to remove the accumulation of contaminants that are in suspension. It is true that oil does not wear out, in the sense that it does not lose its lubricating qualities, but it becomes contaminated with water, sludge, varnish, and acids. How quickly oil becomes contaminated depends on engine operating conditions. Normal wear of the engine deposits metal products into the lubricating system. If oil is not changed regularly, these metal particles, along with contaminants, will be carried throughout the lubricating system, causing excessive wear and contaminant build-up. How often the oil should be changed will vary with climatic conditions, service conditions, and the mechanical condition of the engine. By following manufacturer's recommendations and knowing conditions under which the engine will operate, the oil will be changed at proper intervals.

b. The following seven steps are a general guide to changing oil:

(1) Drain the crankcase when the engine oil is hot. Immediately after running the engine, the hot agitated oil and its contaminants will flow out more completely.

(2) Change oil filter.

(3) Inspect and clean crankcase ventilators and breathers.

(4) Clean, replace, and tighten drainplug.

(5) Fill engine with new oil. Consult operator's manual for proper type and grade of oil.

(6) Operate engine to check oil pressure and detect leaks at plug and filter.

(7) Enter date of oil change and hours shown on the hour meter in the records.

3. Some of the Major Functions of Engine Oils

Due to higher compression, speeds, and temperature in today's complex engines, oils must be able to carry out several necessary functions. The following are some of the most important.

a. Oil must reduce friction and wear. Scuffing and scoring of moving parts is caused by their constant metal-to-metal contact. To prevent this metal-to-metal contact the oil must maintain enough thickness or viscosity to provide a constant film or cushion between the moving parts under severe operating temperatures. However, engine oil should be no thicker or its viscosity should be no higher than necessary to give good starting and still provide the least friction under constant operation.

b. Oil must cool moving parts, by absorbing and dissipating heat. Many engine parts depend completely on the circulation of the lubricating oil for their cooling. These include main and connecting rod bearings, the wrist pins, and pistons. Pistons are cooled by direct heat transfer through an oil film to the cylinder wall and on to the cooling system. This film of oil comes in the form of a jet spray directed to the upper end of the connecting rod and wrist pin bushing.

Bearing failure is often caused not by the lack of oil lubrication but by the lack of cooling from the circulating oil. As oil flow stops, bearings and journals expand from heat buildup. The continued expansion simply creates more heat and then more expansion. The final result is complete seizure of moving parts.

c. Oil helps seal the cylinder against losses of gases from the combustion chamber past the rings and into the crankcase.

d. Oil keeps engine parts clean. Engine oils have always helped in the carrying of soot and contaminants from the oil stream to the oil filter where they can be picked up and held for later removal. Additional contaminants are removed as oil is drained. The use of modern detergent oils has practically eliminated contaminants from coagulating and settling out of the oil. These contaminated oils used formerly, when allowed to settle, resulted in the formation of gums, sludge, and varnish on vital engine parts. The deposits eventually resulted in a stuck compression ring, clogged oil rings, and sluggish valve and rocker arm action. This eventually resulted in early engine overhaul.

e. Oils should also protect against rust and corrosion, which are usually a result of low temperature operation and short interval service. Rust and corrosion, an actual result of condensation of water vapors moving to the crankcase, can be prevented by running a machine long enough to make sure that the engine has reached operating temperature and by using oils that contain additives provided for the purpose of keeping the engine clean.

Transparency No. 3

4. Changing the Oil Filter

The purpose of the oil filter is to remove impurities from the oil such as abrasives and other foreign materials. Most engines are equipped with some type or types of oil filters.

a. There are two major types of oil filtering systems. One is known as the "by-pass" system where a small amount of oil leaves the oil pump (about one-tenth to one-thirtieth) and passes through the filter. In the other system, "full-flow", the entire amount of oil in the crankcase moves through the filter unless it is blocked by dirt or the oil is very cold. Filters are also classified according to the way the oil enters and flows through the filtering material. Examples are as follows:

Surface Filters - These filters strain the particles of dirt as the oil passes through a straight line path through the holes. The holes are smaller than the dirt particles; therefore, as the particles hit the surface, they fall into the filter reservoir. These filters are made of either wire mesh, stacked metal,or paper disks.

Depth Filters - The depth filters are absorbent or adsorbent. The absorbent filters will trap porous materials, soak up water,and soak up impurities. The cotton, wood, wool,or paper material reacts like a sponge that takes in water. The adsorbent filters are chemically treated so they attract and remove impurities.

b. Most tractors are equipped with either a replaceable filter where the element is a part of the bowl or the cartridge type element where the element is replaced in the filter bowl. These cartridges contain a pleated paper element material that has been treated or an element material made of waste fiber.

c. Steps in changing a filter are as follows:

   (1) Check the operator's manual to determine the location of the filter if the location is not known.

   (2) Remove dirt from the filter and filter area with a clean cloth.

      (a) If the filter has a drain plug, remove the plug and catch the oil, then remove the through bolt holding the bowl in place.
      (b) Remove the cartridge from the bowl and dispose of it. Wash filter bowl in diesel oil or kerosene.
      (c) Insert new cartridge or filter in bowl and replace it on engine using new gaskets. Usually the filter is rotated until contact is made by the gasket and base, then the filter is turned an additional one-half turn to seat it firmly.
      (d) When replacing a disposable type filter, tighten it enough to form a good seal. If filters are tightened too much, they damage the gasket.

   (3) Operate the engine for a few minutes and check for leaks.

References:

1. Promersberger, William J., and Others, Modern Farm Power, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1971

2. "Fundamentals of Machine Operation - Preventive Maintenance", Deere and Company, Moline, Illinois, 1973

3. "Fuels and Lubricants, Selecting and Storing", American Association for Vocational Instructional Materials, Athens, Georgia, 1973.

4. "Tractor Maintenance, Principles and Procedures", American Association for Vocational Instructional Materials, Athens, Georgia, 1975

OILS FOR SPARK-IGNITION ENGINES

CHART I

SAE Letter Designation	API Brief Identification and Service Description	ASTM Engine Oil Description
SA	Utility Gasoline - Service typical of engines operated under mild conditions where protection from compounded oils is not required. This classification has no performance requirements.	Straight mineral oil, no additives.
SB	Minimum Duty Gasoline Engine Service - Service typical of engines needing only minimum protection of compounding because of mild conditions used since the 1930's. Provide anti-scuff capability and resistance to oil oxidation and bearing corrosion.	Contains some anti-oxidant and anti-scuff additives.
SC	1964 Gasoline Engine Warranty Service - Service provides for gasoline engines in 1964 through 1967 models of cars and trucks operating these years. These oils provide for control of high and low temperature deposits, wear, rust, and corrosion in gasoline engines.	Intended for use in motor vehicles. Provides anti-sludge and anti-rust properties.
SD	1968 Gasoline Engine Warranty Service - Service provides for gasoline engines in passenger cars and trucks beginning in 1968 through 1971 models operating under manufacturer's warranty. These oils provide for more protection from high and low temperature engine deposits, wear, rust, and corrosion in gasoline engines than oils for API Service Classification SC and may be used when the SC oils are recommended.	Provides low temperature anti-sludge and anti-rust performance.
SE	1972 Gasoline Engine Warranty Service - Service provides for gasoline engines in 1972 models operating under manufacturer's warranties. These oils provide for more service for protection of higher compression engines and the lower compression engines with bigger bores that are designed for low-lead gasoline.	Provides protection for 1972 model car and truck engines.

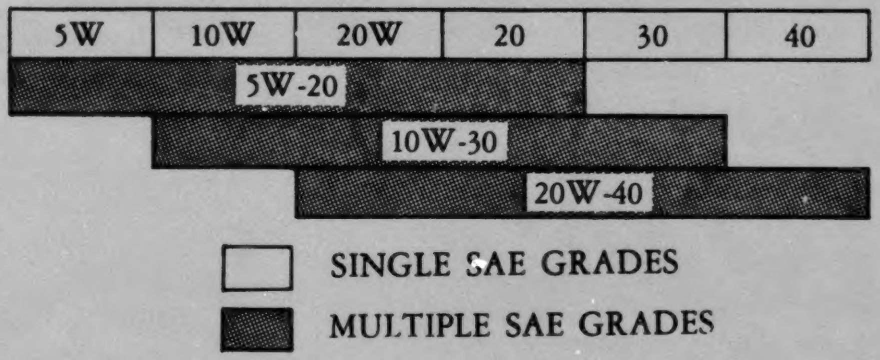
OILS FOR DIESEL ENGINE SERVICE

CHART II

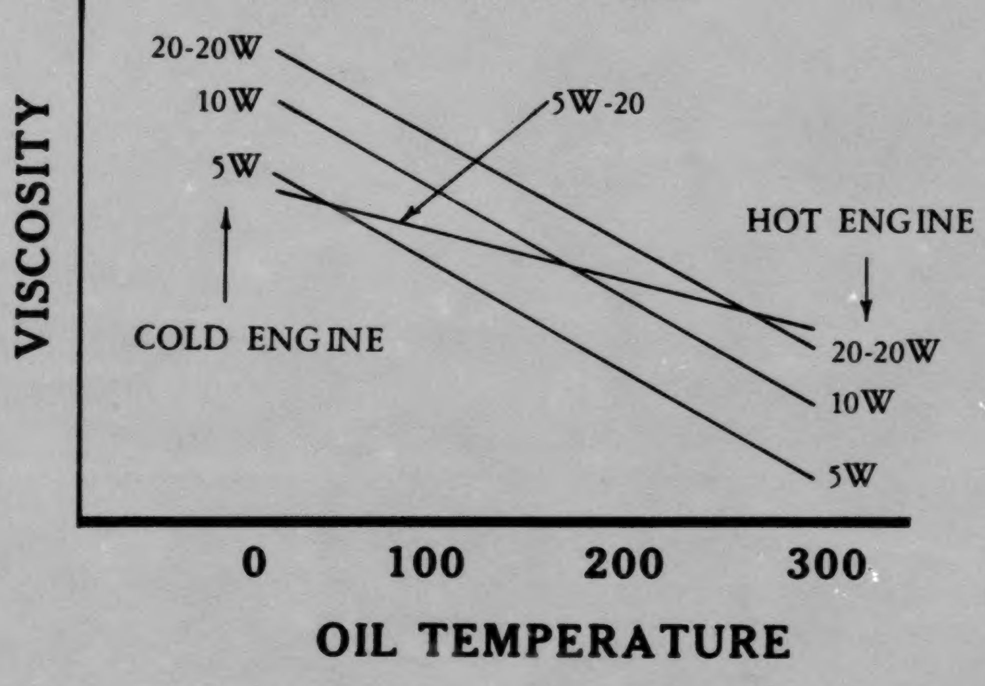
SAE Letter Designation	API Brief Identification and Engine Service Description	ASTM Engine Oil Description
CA	Light Duty Diesel Engine Service - Provides service for diesel engines in mild to moderate duty with high quality fuels. This type oil was widely used in natural breathing engines when using fuels of such high quality that they imposed no unusual requirements for deposit and wear protection.	Oils meet the requirements of MIL-L-2104A. For use in gasoline and naturally aspirated diesel engines that are operated on low sulphur fuel. MIL means U. S. Army or Military.
CB	Moderate Duty Diesel Engine Service - Provides service for diesel engines operated in mild to moderate duty, but with fuels of lower quality which require more protection from wear and deposits. These oils were introduced in 1949. They provide protection from bearing corrosion and from high temperature deposits in normally aspirated diesel engines with higher sulphur fuels.	Oil is used in gasoline and naturally aspirated diesel engines. Includes MIL-L-2104A oil when diesel engine test was run with high sulphur fuel.
CC	Moderate Duty Diesel & Gasoline Engine Service - Provides service for lightly supercharged diesel engines operated in gasoline engines. These oils were introduced in 1961 and used in trucks, industrial and construction equipment, and farm tractors. Protection is provided for high temperature deposits in lightly supercharged diesels and from rust, corrosion, and low temperature deposits in gasoline engines.	Oils meet requirements of MIL-L-2104B. Provides low temperature, anti-sludge, anti-rust, and lightly supercharged diesel performance.
CD	Severe Duty Diesel Engine Service - Provides service for supercharged diesel engines in high speed, high output use requiring highly effective control of wear and deposits. These oils provide protection from bearing corrosion and from high temperature deposits when using fuels of a wide quality range.	These oils meet the requirement of the U. S. Army and engine maker's specifications. The MIL-L-45199B specification was issued in 1968.

ENGINE OILS

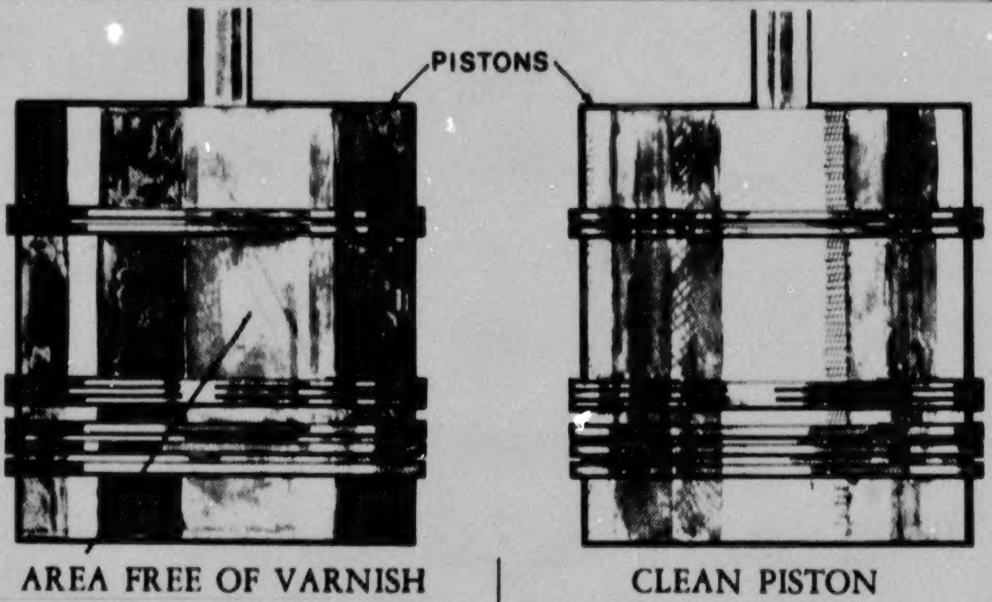
COMPARISON OF MULTI- GRADE WITH SINGLE GRADE OILS



VISCOSITY OF OIL

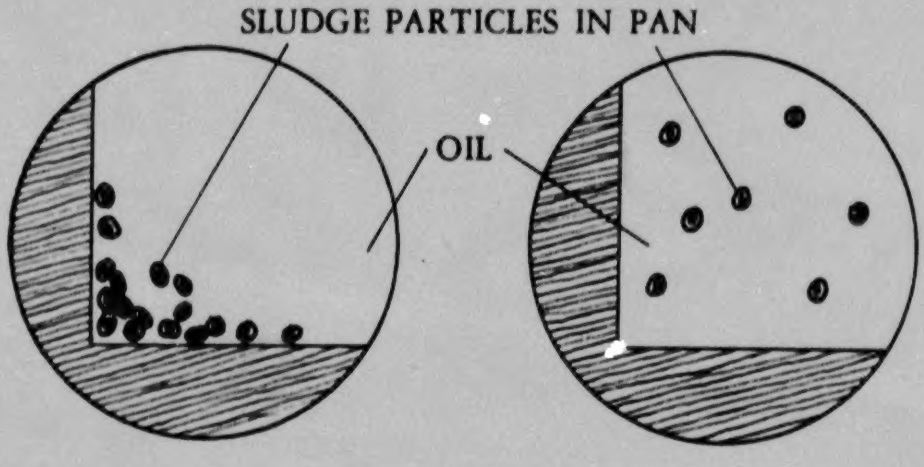


ENGINE OIL ADDITIVES


PISTONS
AREA FREE OF VARNISH
CLEAN PISTON

LACK OF OXIDATION INHIBITOR IN OIL

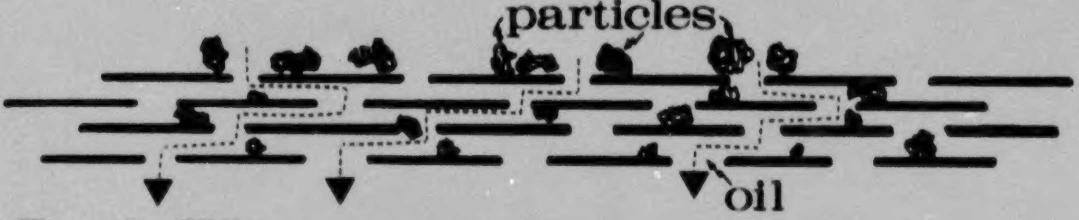
PROPER OXIDATION INHIBITOR


SLUDGE PARTICLES IN PAN
OIL

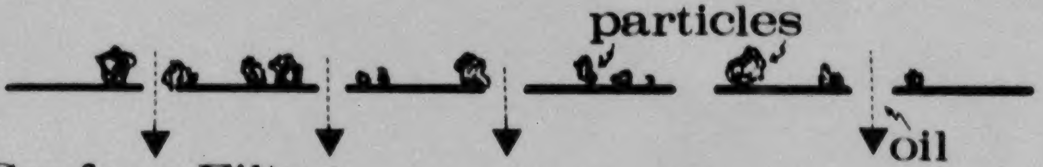
NO DETERGENT

WITH DETERGENT

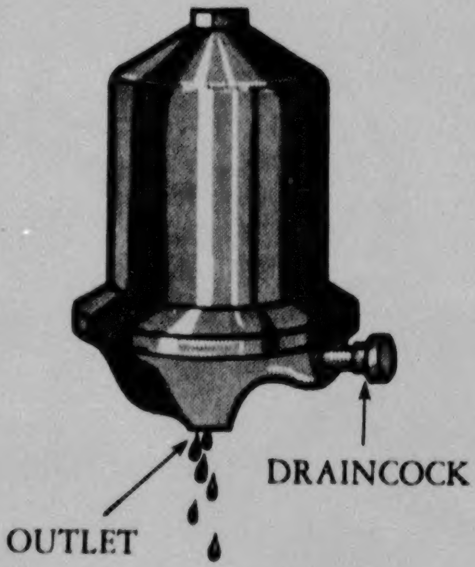
CHANGING OIL FILTER

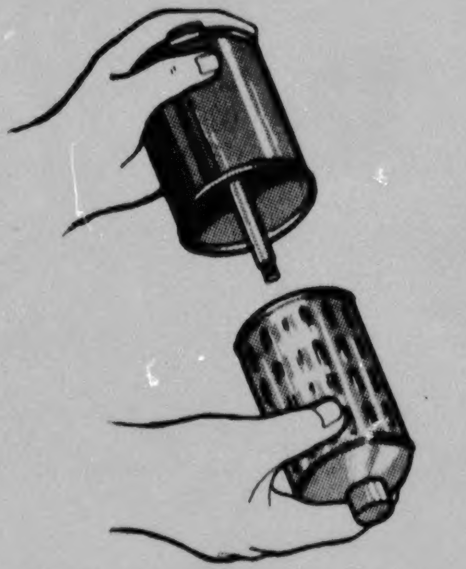

particles
oil

Depth Filter


particles
oil

Surface Filter


DRAINCOCK
OUTLET



REPLACING FILTER ELEMENT

GENERAL AGRICULTURAL MECHANICS

Unit F: Lubricating Power Units

Topic 2: Servicing the Transmission, Differential, and Hydraulic Systems

Suggested Procedures and Activities: An exhibit of new and used gear oils will be helpful during the classroom discussion.

1. The Importance of Properly Lubricating a Transmission

   a. Most tractor and special machine transmissions are under a constant strain when used in hard service. This turning, splashing, pumping, heating, and cooling of transmission oil causes it to thicken and oxidize. There could also be a loss of additives with continuous use.

   Transmission oil becomes contaminated with dust, rust and metal particles, and the condensation of moisture. The continuous shifting of gears causes some chipping as well as normal wear of gear parts. Bearings can be easily damaged by metal chips. Once the surface of a race or roller in a bearing is blemished, that part tends to wear more rapidly. If worn bearings allow the shafts to move out of line, then more gear wear develops.

   b. It is recommended that gear-case (transmission) lubricants be changed at least once per year. Some tractor manufacturers recommend that transmission lubricants be changed every 1,000 hours of operation if the tractor is operating under normal conditions.

Transparency No. 1

2. Types of Drive Units

   a. There are several (at least six) types of power train designs being used on modern tractors. Some of these designs are:

      (1) Gear drive units housed and lubricated in a single compartment with the hydraulic system either separate or as part of the system.

      (2) Two compartment units that house part of the transmission differential and final drive in one reservoir and the other part of the

transmission and wet clutch in the other reservoir. The hydraulic system is supplied from the wet clutch compartment.

(3) Three compartment units that are divided into the torque converter and wet clutch; final drive, differential and transmission; and power-take-off compartments. The hydraulic system gets its fluid from the PTO compartment.

(4) Four compartment systems made up of separate compartments for the hydraulic, PTO, belt pulley, and the major gear unit (final drive, differential, transmission).

These first four power train designs are lubricated by gears lifting the oil in the gear case. However, some units are equipped with pumps that spray oil on the gears.

(5) Differential and hydrostatic transmissions housed in one large compartment.

3. Gear Oils

Gear oils are those used in enclosed gear boxes to lubricate differentials, transmissions, and steering gears. These gears are used to increase torque, change speed, and change the direction of rotation in the drive mechanism. Today's gears are relatively small gears and work under closer tolerances in modern high-speed, high torque gear trains. The result is higher tooth loads and harder rubbing between mating gears. This makes proper lubrication even more critical. Unless a good film of lubrication is maintained between mating gears, they will wear and scar.

a. Gear Lubrication Principles - Gear oils must match the gear load. In small, simple gear drive units, where there is light tooth pressure, a simple gear oil is adequate. For heavy gear loads, oils must have special "anti-friction" and "anti-weld" agents. These additive type oils are known as extreme pressure or hypoid lubricants. Spiral bevel and worm gear types wear rapidly unless these additive type oils are used.

b. Gear Oil Requirements - Gear oils for today's work conditions should have the following properties:

(1) Extreme Pressure Properties - Hypoid, heavy loaded spiral bevel, and worm gear combinations need extreme pressure properties.

(2) Oxidation Stability - Gear oil must resist oxidation and sludge formation under severe heat and under violent agitation and air foaming.

(3) Viscosity - Gear case and surrounding machine temperatures require higher viscosity.

(4) Corrosion Resistance - Corrosion additives act to protect gear teeth. Some discoloration of gears and internal parts does not always indicate corrosion.

(5) Foam Resistance - Most gear lubricants contain a foam suppressor.

(6) Pour Point - The pour point must be low enough to allow lubrication at lowest expected temperatures.

(7) Channel Temperature - Gear oils should be fluid enough at low temperature to allow oil to recover a metal surface after a gear tooth has mashed an oil covering away. This oil when mashed away will form a channel to allow constant metal-to-metal contact if it is not fluid enough to return after gear tooth pressure is relieved.

c. SAE Gear Oil Classification - Gear oil classification as established by the Society of Automotive Engineers (SAE) is based on viscosity alone and has no indication of quality or service. To avoid confusion in the designation of gear oils and engine oils, a particular gear oil is assigned a higher SAE number than an engine oil of the same thickness. For example, SAE 80 gear oil has about the same viscosity as SAE 20 engine oil.

d. API Gear Oil Service Classification - The American Petroleum Institute (API) designates gear oils by the service for which they are suitable. The following are the API service classes: API GL-1 through API GL-6. For example, API GL-3 is used in manual transmissions and spiral bevel gear axles under moderate speed and load.

4. Transmission - Hydraulic Fluids

a. Many farm and industrial machines have a common reservoir for the transmission and hydraulic systems as mentioned previously. These types of systems cause the gear train, differential, hydraulic clutches, disk plates, along with the hydraulic system and power steering to all have the same lubricating fluid. Fluids designed for this purpose are referred to as "four-way" oils because of the wide range of services they perform. Each manufacturer has a specific oil for its own equipment. These oils must exhibit the following properties:

(1) Provide high oxidation stability for long life and protection

(2) Low pour point for low temperature service and cold starting

(3) High viscosity index for best viscosity under different operating temperatures

(4) Provide additives for extreme pressure under heavier loads

(5) Provide rust and corrosion inhibitors

(6) Be compatible with all seal types

(7) Contain foam suppressors

b. While no transmission hydraulic fluid will fully meet each specific job of every machine, products are available that will meet the service requirements in any one machine for which the oils are specified. For whatever job requirements it is best to always use the oil specified by the manufacturer.

5. Hydraulic Fluids

a. The functions, properties, selection, and filter information are as follows: the most important function is to transmit power. The fluid should be stable over a long period and it must protect the system against rust and corrosion. It should also act as a lubricant and heat absorbent for working parts.

Even though fluid is not considered a lubricating fluid, it is involved in the servicing of the drive mechanism.

b. Some of the properties of hydraulic fluids are:

(1) Viscosity - Viscosity is the most important single property of hydraulic fluid, because of the need to create and maintain necessary pressures for close fits. Too-low viscosity causes leaks within the system; too-high viscosity causes sluggish operation, heating, and high pressures.

(2) Stability - The need for stability is very important where fluids are subjected to heat, agitation, and aeration which are factors contributing to oxidation and deterioration. When oils are used for long periods oxidation inhibitors are necessary.

(3) Corrosion Resistance - Since rust and acid corrosion is directly associated with oxidation and the introduction of moisture and foreign particles through the breathing vents, hydraulic oils should contain a very potent rust inhibitor. These inhibitors act by displacing water from metal surfaces, then adhering to these same parts to prevent water-to-metal contact. Acid corrosion can be further controlled by oil coolers or coils or radiator coolant circulating through the hydraulic oil reservoir.

(4) Pouring Point - Pouring point depressants are of prime importance in conditions of extreme cold.

(5) Anti-Foam - Foaming in hydraulic systems, caused by severe agitation of moving parts in the presence of air, air leaks in the system, or by contaminants such as dirt and water, is a chronic problem that must be dealt with as such. The use of silicone materials does not prevent the problem of foaming but causes the foam bubbles to be very unstable and break down rapidly.

(6) Anti-Wear - Hydraulic pumps, especially vane type, are susceptible to wear. Manufacturers of pumps recommend oils that contain anti-wear compounds.

(7) Compatible with Seals - Seals in hydraulic systems contain rubber and rubber type materials that could deteriorate if oil contains harmful materials. This demands that oil be made compatible with the seals in the engine.

The properties of hydraulic fluids are very similar to the engine oil properties, and the selection of the proper fluid is the same. That is, there are specific fluids for certain types of machines and service. The manufacturer of the machine recommends the proper oil, and such recommendations should be followed.

6. Draining and Refilling the Drive Mechanism

a. Transmission System - The following steps may be used to drain, flush, and refill the transmission system:

(1) Operate the machine until the gear oil is heated and well agitated in the compartment. Dirt and other foreign material will be mixed in the well agitated oil.

(2) Be certain that the machine is parked on a level surface. Remove the transmission plug or the transmission and differential plugs if the units are housed in different compartments. On machines that have the final drive in a separate compartment, remove the third plug. It may be necessary to use a metal shield to divert the oil away from the tire when draining the final drive.

(3) If the drain plugs are magnetic, remove metal particles by striking the plugs against a solid object then wipe clean.

(4) If the machine has a transmission oil filter, replace it.

(5) If the operator's manual recommends flushing the gear case, use the following steps:

   (a) Replace the plug(s) and fill the gear case as recommended (1/3 to the gear oil level) with proper flushing liquid (flushing oil, diesel fuel, or kerosene).
   (b) Operate the machine without a load for several minutes, park on a level location, and drain again.
   (c) Remove foreign material from drain plugs and replace.

(6) Use clean cloth to clean the filler plug and plug area, then fill with the proper lubricant. Fill only to proper level to eliminate excessive foaming and agitation. Replace filler plug properly.

(7) If the unit is equipped with cap and breather, clean the breather in kerosene, shake out excess, add a small amount of light weight oil to the breather filter, and shake again before replacing.

(8) Refill the transmission gear case and check the level by using the dip stick.

It is very important that the proper type of fluid be used, especially if the hydraulic unit operates by using the same fluid as the transmission.

b. Hydraulic System - Contaminants or foreign material and oxidized fluid should usually be removed by draining and flushing the system at least once per year. The following steps may be used to service the system:

(1) Operate the system until it has reached the normal temperature. It is necessary to drive the machine if the same fluid is used for the transmission.

(2) Remove the drain plug, catch the fluid in a container, and replace drain plug.

(3) Remove the filter element in the same manner as removing a crankcase filter element and clean the filter housing and screen. Always use a lint-free cloth to clean the housing. Install and reassemble filter.

(4) Flush the system if recommended by the operator's manual. A close inspection may reveal an oily film or a lacquer formation. The flushing procedure may be as follows:

(a) Add new hydraulic fluid or oil and operate the unit to circulate the oil throughout the system.
(b) Reinspect for cleanness and solid formations. If gum or lacquer formations cannot be removed, disassemble and clean each part manually.
(c) Remove filter or filters and replace before refilling the system.

(5) The system may be refilled as follows:

(a) Clean area around and on the filler plug before removing it.
(b) Refill reservoir to recommended level with clean or new hydraulic oil. Replace the filler plug or cap before attempting to operate the machine.
(c) Operate the engine and system for a few minutes and then recheck the oil level by using the dip stick; add additional oil if necessary.
(d) If the machine has a breather, it should be cleaned by washing in a clean oil solution. Kerosene is considered a good cleaning fluid for breathers.

The hydraulic systems on modern machines consist of implement-control, power steering, power brakes, hydraulically operated transmission, torque converter, and front wheel drive units. Only the implement control system is discussed in this topic; however, the servicing of other hydraulic systems is similar to servicing an implement control system.

References:

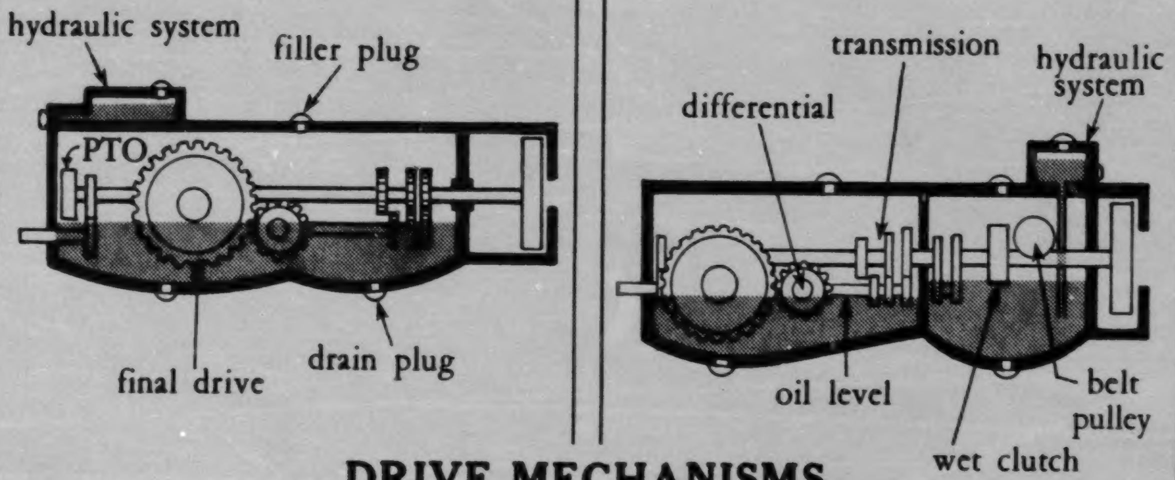
1. "Tractor Maintenance, Principles and Procedures", American Association for Vocational Instructional Materials, Athens, Georgia, 1975

2. "Fundamentals of Machine Operation - Preventive Maintenance", Deere and Company, Moline, Illinois, 1973

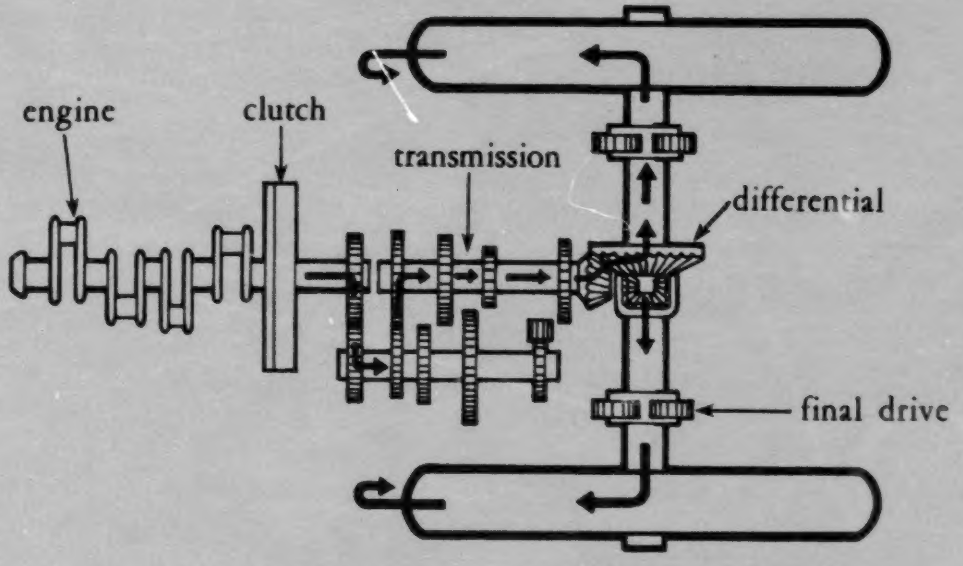
SERVICING DRIVE & HYDRAULIC SYSTEMS

ONE COMPARTMENT

TWO COMPARTMENT


hydraulic system
filler plug
PTO
final drive
drain plug
transmission
hydraulic system
differential
oil level
belt pulley
wet clutch

DRIVE MECHANISMS


engine
clutch
transmission
differential
final drive

POWER TRAIN UNITS

GENERAL AGRICULTURAL MECHANICS

Unit F: Lubricating Power Units

Topic 3: Lubricating the Chassis - Cleaning and Lubricating Bearings

Suggested Procedures and Activities: Samples of several types of greases may be used as valuable teaching aids during the classroom discussion.

1. Functions of Greases

   a. Greases are considered as solid or semi-solid lubricants. They are made from blends of lubricating oils that have soaps containing additives and stabilizers added. The type of soap and stabilizer actually determines the type of grease. The most common soaps and their uses are:

      (1) Lithium Soap - Multi-purpose grease.

      (2) Calcium Soap - Chassis grease.

      (3) Sodium Soap - Wheel bearing grease.

      Table I shows the more common soaps and non-soaps that make up the various types of greases. Other factors are given to help determine grease types and characteristics.

   b. Some specific jobs of the different types of greases include:

      (1) Multi-Purpose Greases - This grease is not necessarily for a specific job, but is unique because it is used for many jobs. This grease can be used on wheel bearings and almost all fittings. It is water resistant, will withstand high temperature, will last a long time, and will protect against rust. It can also have the same qualities of high-temperature as extreme pressure greases.

      (2) High-Temperature Greases - High-temperature greases are formulated to resist heat and not liquify. Special thickeners are used in the place of soaps.

      (3) Extreme-Pressure Greases - Extreme pressure (E. P.) greases have an ability to maintain a film on metal surfaces to prevent wear with slow motions or thick sliding loads. Molybdenum disulfide or lead naphthenate are additives used to get this quality.

c. Grease additives include soaps, non-soaps thickeners, fillers, and special chemical additives (stabilizers).

Fillers are added to give bulk and hardness to grease. Many additives in grease are the same as in engine, hydraulic, and transmission oils. They serve as inhibitors of corrosion and oxidation and anti-scuff agents. Special chemicals are added to increase the temperature dropping point as the grease liquifies.

Transparencies Nos. 1 and 2

2. Lubricating Parts of A Machine that Requires Grease as a Lubricant

   a. The front wheel bearings should receive special lubrication care even though they are protected from dirt and other contaminants by seals. The rear wheel bearings are usually lubricated from the lubricant carried in the differential or final drive. If the wheels are equipped with grease fittings, they may be lubricated daily or as recommended by the operator's manual. Once or twice each year the front wheels should be removed and the bearings greased. The procedure is as follows:

      (1) Put the machine in gear, set the parking brake, and block the rear wheels back and front. Use a jack to lift the front wheel and then place support block or a support stand to protect the wheel from falling from the jack. When packing tricycle dual wheels, one wheel can be freed by running the other up onto a block.

      (2) Clean and remove the hub cap. It may be bolted on, screw-in, or slip-on type.

      (3) Remove cotter pin, nut, thrust washer, and bearing. Place all these parts in a clean container or on a clean rag. Dirt must be kept away from these internal wheel parts.

      (4) Remove wheel from the spindle. If the bearing and seal are not the type that stay in place in the wheel, protect the bearing from falling from the wheel. On some machines the grease seal remains on the hub and is removed with the fingers. On the type that the inner bearing remains in the hub, the bearing and seal can be forced out by using a drift punch or wood dowel.

      (5) Steps that may be used to clean and pack front wheel bearings are:

(a) Place the bearing in a kerosene or diesel oil solution. Remove soft grease by washing in solution using the hand or a paint brush. Use a stiff bristle brush to remove hard deposits. It may be necessary to clean a bearing on the spindle if it is too difficult to remove.

(b) Dry the bearing with either compressed air or a clean cloth.

(c) Examine the bearing, grease retainer ring, and seal for damage or excessive wear. It may be necessary to replace the old seal with a new one each time the wheel is packed.

(d) Use the same cleaning solvent to clean the spindle, hub, and hub cap.

(e) Pack the clean bearing with grease by working grease between rollers. A twisted cloth may be used to force grease into the bearing left on the spindle. Place a heavy layer of grease on the bearing before using the cloth and hand to force grease into the bearing.

(f) Remove excess grease by rotating the race, then replace the inner bearing on the spindle after the washers and grease retainer.

(g) Place a layer of grease on the inside of the hub and the spindle and position wheel on the spindle.

(h) Install the grease packed outer bearing, thrust washer or retainer, and , in some cases, felt washers ahead of placing the bearing adjusting nut.

(i) Tighten the slotted adjusting nut until it drags, then loosen it to the first or nearest slot over the cotter key hole. Some operator's manuals may suggest the nut be loosened about 1/6 turn.

(j) Insert cotter key in hole, binding one leg up over the spindle and the other toward the wheel over the flat surface of the nut. After this step replace the hub cap.

(6) Other areas on some machines that should be lubricated by greasing are:

(a) Clutch and brake pedals
(b) Three point hitch
(c) Front-end
(d) Rear axle outer bearing
(e) Tie rods, links and pivot

(7) Suggestions for applying greases include:

(a) Follow the manufacturer's recommendation as to which type and how much grease to use.

(b) Always wipe off grease fittings before injecting new grease. If dirt is on the end of the grease zert, it will be pushed into the grease system. Wipe off any excess grease after greasing.

Usually two or three strokes applied to a greas fitting (jet) with a grease gun will supply sufficient grease to lubricate the part and flush out a portion of the old grease. Some grease areas are completely sealed; therefore, grease cannot be flushed out.

3. Storing and Handling Lubricants

a. Purpose of Storing Lubricants - Use care in storing and handling lubricants. By using a few simple precautions lubricants can be kept free of dirt, moisture, excessive heat, and excessive cold.

b. Precautions to follow in protecting lubricants:

(1) Store oils inside whenever possible, in clean, closed cabinets, and protective cartons. If stored outside, lubricants should be kept in water-tight air-tight drums.

(2) Keep oil bungs tight on drums.

(3) Rinse oil containers, funnels, and spouts in solvent after use. They should also be kept covered, or stored upside down.

(4) Clean all dirt from around filler caps when adding oil.

(5) Clean areas around oil filter containers and screw-on type cartridges.

(6) Keep grease cartridges for grease guns in protective cartons to prevent crushing and allowing entrance of contaminants.

(7) Clean grease zerts before attaching the grease gun, and if there is a leakage of grease around the zert, do not reclaim this grease. Remove it with paper or a rag and dispose of the waste.

(8) Do not use any unused portions of grease that are left standing in partially filled containers where the top is left off or the container opening is unprotected.

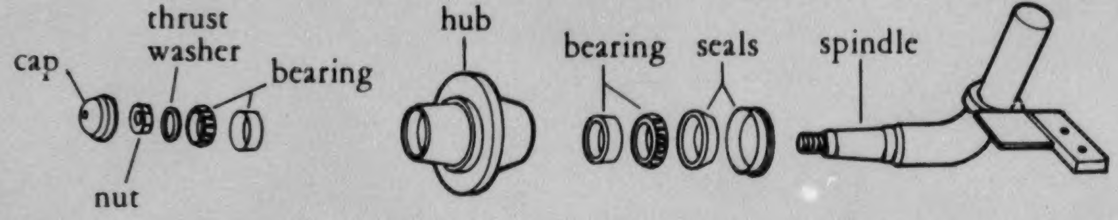
References:

1. "Fundamentals of Service - Fuels, Lubricants, and Coolants", Deere and Company, Moline, Illinois, 1970
2. "Fuels and Lubricants, Selecting and Storing", American Association for Vocational Instructional Materials, Athens, Georgia, 1973
3. "Fundamentals of Machine Operation, Preventive Maintenance", Deere and Company, Moline, Illinois, 1973
4. "Tractor Maintenance, Principles and Procedures", American Association for Vocational Instructional Materials, Athens, Georgia, 1973

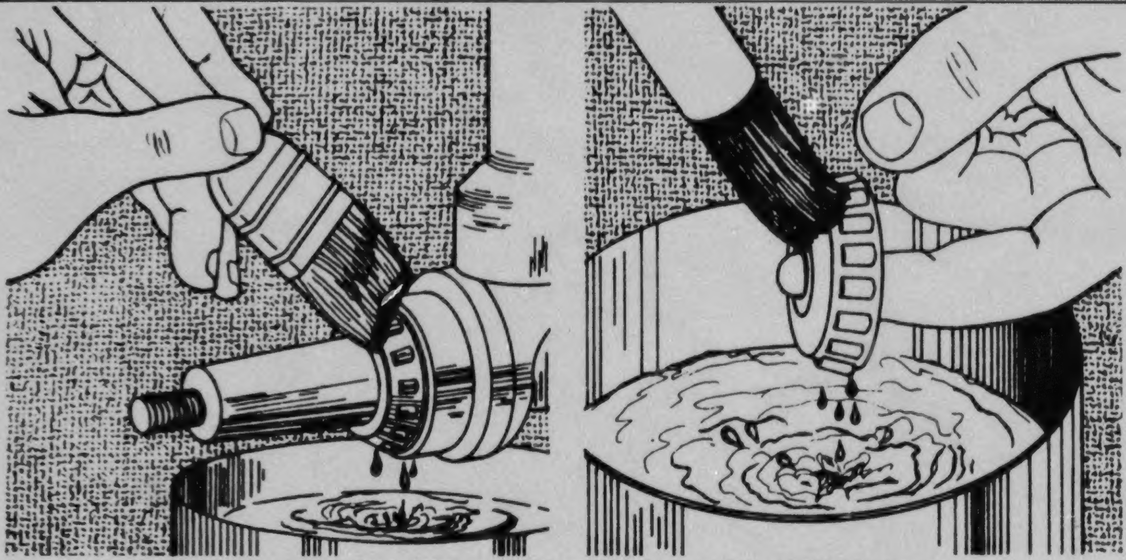
MAJOR CLASSES OF GREASE AND THEIR PROPERTIES
TABLE I

Class	Kind	Properties
Lime Soap	Cup	Smooth and water resistant, but separates on loss of moisture, loses some consistency on working.
Lime Soap	Complex	Does not resist moisture, contains some fiber, changes consistency on aging.
Soda Soap	Sponge or Fiber	Does not resist water, will not separate at operation temperature, consistency loss varies.
Soda Soap	Black	Does not resist water, smooth and hard, will not separate at operational temperature.
Soda Soap	Medium to Short Fiber	Does not resist water, smooth consistency varies, will not separate at operational temperature.
Non-soap	Multi-purpose	Resists both heat and water, is stable at a high temperature, chemically and mechanically stable, smooth.
Lithium Soap	Multi-purpose	Resists heat and water, will not separate at high temperatures, some loss in consistency on working.
Residuum	Compound for Gears & Pinions	A type of adhesive grease, resists water and serves as a grease under pressure, smooth.

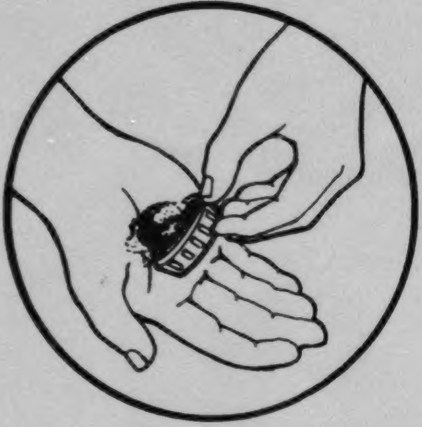
LUBRICATING MACHINE PARTS


cap
thrust washer
bearing
nut
hub
bearing
seals
spindle

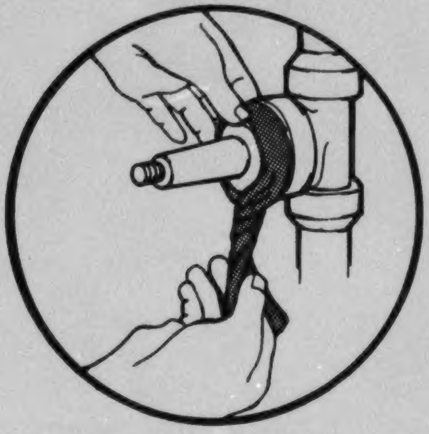
FRONT WHEEL ASSEMBLY



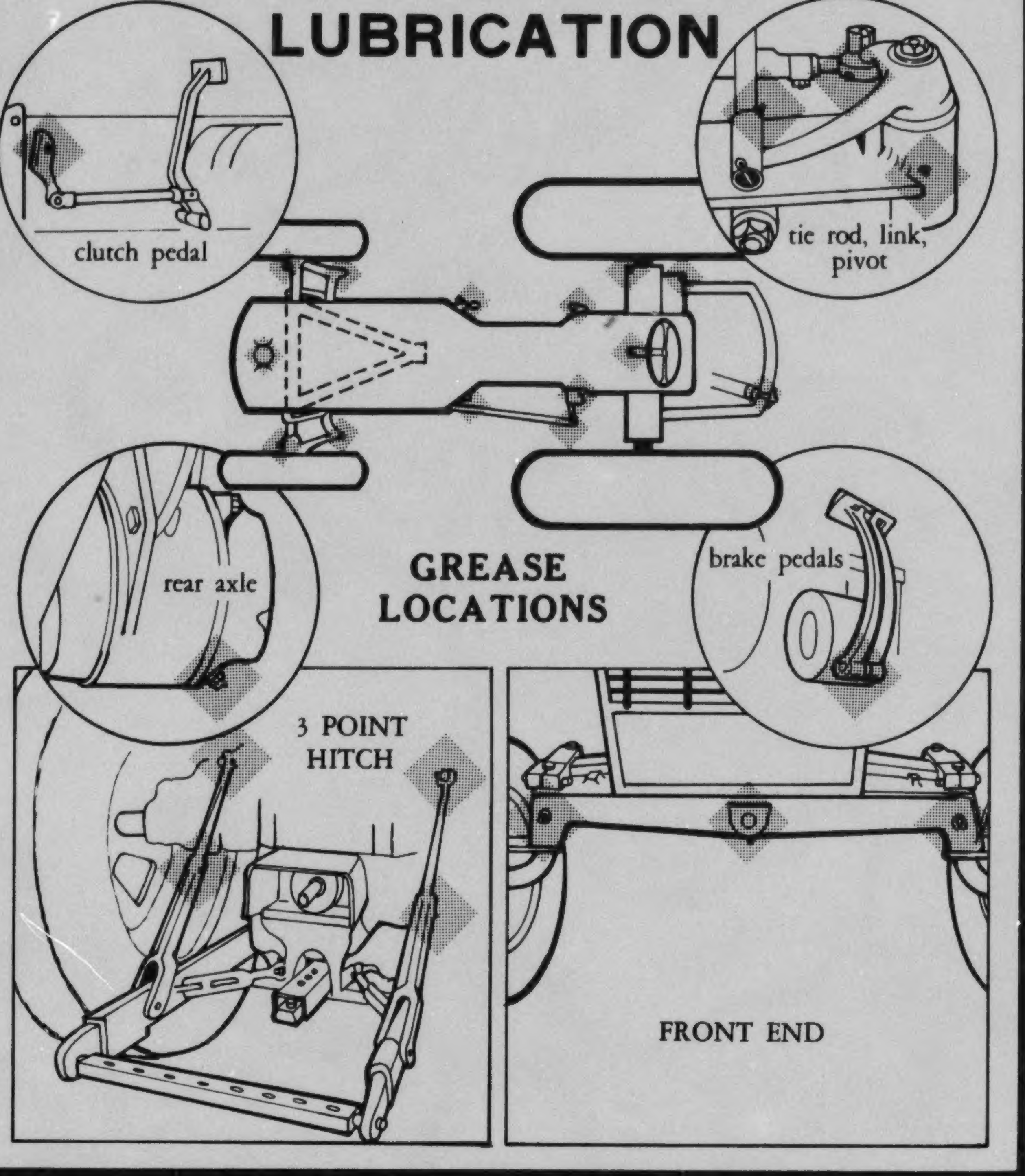
CLEANING WHEEL BEARING



PACKING
WHEEL
BEARING



OTHER AREAS OF LUBRICATION


clutch pedal
tie rod, link, pivot
rear axle
GREASE LOCATIONS
brake pedals
3 POINT HITCH
FRONT END

GENERAL AGRICULTURAL MECHANICS

Unit G: Servicing an Air Conditioning System

Topic 1: Inspecting an Air Conditioning System

Suggested Procedures and Activities: After the class discussion the students may visit the shop where they can see an air conditioning unit in operation on a tractor or in an automobile. They should be able to name the parts and explain the refrigeration cycle.

1. Basic Functions of an Air Conditioning Unit

   a. A proper functioning air conditioning unit will take the air that enters the cab of a machine and clean, cool, and dehumidify it. Refrigerant-12 is used in a system to remove heat from the air. This type of refrigerant may be known as Freon-12, Prestone-12, Isotron-12, and other brand names.

Transparency No. 1

   b. The four basic elements and other parts of a system and their functions are:

      (1) Compressor - The compressor circulates the refrigerant. It receives low pressure gas and converts it to high pressure gas. It is usually operated from a belt that operates off the engine crankshaft. Another very important function of the compressor is to concentrate heat. A small amount of heat is added to the refrigerant as the compressor operates.

      (2) Condenser - This part of the system converts or condenses the high pressure gas from the compressor to a liquid. The condenser resembles a radiator and functions in a similar manner, in that heat is carried off as air passes over the coils. Slow moving machines are equipped with forced air (electric fan) condensers. The air is blown over the coils by a blower fan.

      (3) Expansion Valve - This valve removes pressure from the warm high pressure refrigerant. As the liquid leaves the valve and

moves to the evaporator it becomes a low pressure cold liquid. The liquid is metered at this point and the pressure reduced.

(4) Evaporator - The evaporator converts the low pressure liquid to a low pressure gas, by absorbing heat from the air. As stated above, the condenser converts gas to a liquid, which is the opposite action of the evaporator. The entrance of the low pressure liquid into the evaporator vaporizes (boils). This action causes the absorption of heat from the cooling fins and core tubes, making them cold. A blower type fan pushes cool air through the evaporator.

(5) Receiver-(Drier) Dehydrator - This part of the air conditioning system serves as a reserve tank for the refrigerant until it is needed by the evaporator. It is located between the condenser and evaporator.

(6) Thermostatic Switch - The thermostat switch controls the operation of the system. The main parts of the thermostat consist of a capillary tube, bellows or diaphragm, capillary bulb, screen, and valve.

2. Checking the System

a. The following points should be observed when visually checking the system:

(1) Check the compressor drive belt for alignment, wear, and tightness. Side wear can result from out-of-lineness. A very tight belt will cause bearing wear, whereas a loose belt will cause slippage. Adjust the belt to about 1/2 inch deflection. Belt adjustment can usually be made by loosening the compressor cap screw and mounting bolts then tighten both after belt is pulled tight.

(2) Check brackets, braces, and all bolts. Mounting brackets may become loose or be broken. This condition will result in failure of the unit. Replace damaged braces and tighten all loose bolts.

(3) Check hose for leaks and chafing. Worn or lost rubber pads and grommets will permit the hoses and copper lines to rub metal. Install a material that will protect hoses and tubes from damage. Check drainage hose for clogging and collapsing.

(4) Examine the condenser for insects and dirt clogging. Use high pressure water hose and wash these foreign materials from the condenser.

(5) Since the evaporator condenses moisture, examine it for dirt and lint on the air intake side. Remove dirt and lint with compressed air.

(6) If the compressor oil level can be checked without removing it from the engine, use the proper dip stick and, if the oil is low, add to proper level. Too much oil may flood the condenser and evaporator.

(7) Where an air filter is used on the system to clean the air entering the evaporator, remove the filter and clean it.

(8) Check the system for leaks. Oily spots may indicate refrigerant leaks. Oily leaks also means the refrigerant is escaping.

(9) Examine the blower motor, air ducts, and louvers. Operate these mechanisms to determine whether or not adjustment and repairs are necessary.

(10) Check the refrigerant level using the following steps:

(a) Refer to the operator's manual, if necessary, for the location of the sight glass. It is usually located near the receiver-drier.
(b) Operate the engine at fast idle and adjust speed of air conditioner to high. Set the temperature control to the coolest temperature. Bubbles can be seen in the sight glass a short time after turning on the air conditioner.
(c) Check to see if the bubbles stop flowing after the unit has operated for a few minutes. The bubbles should disappear if the refrigerant is not low and the temperature is above 70 degrees F.

(11) Anytime the system is brought in for major repair and/or service, check the receiver-drier and replace it. When excessive moisture becomes a problem, it is usually due to the malfunction of the drier.

b. Some common problems and why they appear when operating a system:

(1) Complete lack of cooling

(a) Drive belt loose or broken.
(b) Expansion valve stuck open or closed.
(c) Reed valves in compressor not functioning or the compressor is frozen.
(d) Electrical wire disconnected or broken. Blown fuse.
(e) Solenoid or clutch coil burned, thermostat contacts burned, blower motor burned or disconnected.

(f) Seal leaking at compressor shaft or leaks in other part of the system.
(g) Receiver-drier or expansion valve screens clogged and clogged coil or hose.
(h) Badly damaged (bent) or broken refrigerant lines.

(2) Limited cooling

(a) Slipping compressor clutch.
(b) Air intake filter clogged, evaporator clogged, condenser coil fins clogged.
(c) Obstruction in blower passages.
(d) Air vents admitting outside air to enter the cooling area.
(e) Blower motor operating at a slow speed.
(f) Clogged screen in expansion valve or receiver-drier.
(g) Defective thermostat or thermostat adjusted improperly.
(h) System lacking the proper amount of refrigerant.
(i) Air or a large amount of moisture in the system.
(j) Thermal bulb of the expansion valve lost charge.
(k) Head gasket or reed valves leaking.

(3) System noisy

(a) Worn or loose belt.
(b) Loose air ducts or panels.
(c) Defective idler pulley, bearing, or clutch.
(d) Defective blower motor and fan.
(e) Loose compressor mounting or system lines vibrating.
(f) Low or excessive oil in compressor.
(g) Excessive amount of moisture in the system.
(h) Reed high pressure compressor valve closed.

(4) Excessive pressure in high pressure side of system

(a) Excessive refrigerant or air in the system.
(b) Compressor contains excessive amount of oil.
(c) Restriction in a high pressure line, filter, condenser, receiver-drier. Clogged screens.
(d) Air restricted from the condenser by dirt, insects, or chaff.
(e) Engine running too hot.

(5) Low pressure in high side and high pressure in low pressure side

(a) Defective reed valve.
(b) Worn compressor parts.
(c) Valves (expansion or suction throttle) stuck open admitting too much refrigerant to the compressor.

(6) Normal pressure in the high pressure side and high pressure in the low pressure side

Malfunctioning of expansion valves or expansion valve sensing element malfunctioning.

(7) Normal pressure in the high pressure side but the low pressure side is low

- (a) Thermostat temperature control fails to cut out.
- (b) Clogged screen in the expansion valve or a restriction between the receiver-drier and valve.
- (c) System contains moisture.
- (d) When the low pressure gauge shows a vacuum reading and expansion valve closed.

References:

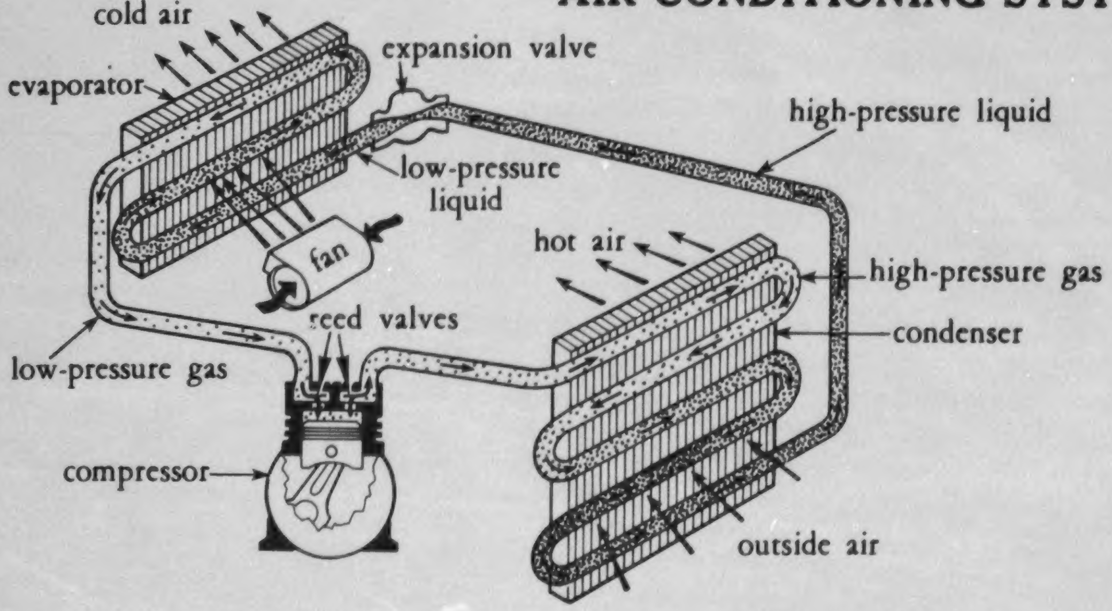
1. Stockel, Martin W., Auto Service and Repair, The Goodheart - Willcox Company, Inc., South Holland, Illinois, 1969

2. "Fundamentals of Service - Air Conditioning", Deere and Company, Moline, Illinois, 1970

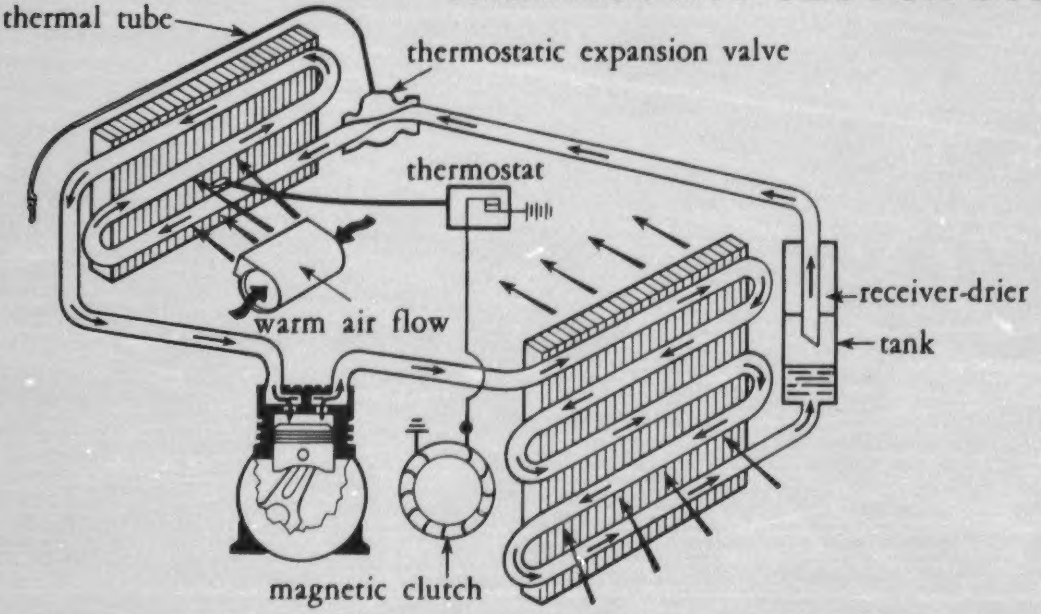
3. "Fundamentals of Machine Operation, Preventive Maintenance", Deere and Company, Moline, Illinois, 1973

AIR CONDITIONING SYSTEMS

AIR CONDITIONING SYSTEM


cold air
expansion valve
evaporator
high-pressure liquid
low-pressure liquid
fan
hot air
high-pressure gas
reed valves
condenser
low-pressure gas
compressor
outside air

THERMOSTAT-CLUTCH SYSTEM


thermal tube
thermostatic expansion valve
thermostat
receiver-drier
tank
warm air flow
magnetic clutch

GENERAL AGRICULTURAL MECHANICS

Unit G: Servicing an Air Conditioning System

Topic 2: Adjusting and Testing the System

Suggested Procedures and Activities: If available use the gauge and manifold set, leak detector, and vacuum pump as teaching aids during the class discussion.

Transparency No. 1

1. The Basic Tools Needed to Test and Service an Air Conditioning System

    a. Gauge and manifold set consists of the following parts:

        (1) A low side (low pressure) compound gauge to register both pressure and vacuum. This means that pounds per square inch (psi) and inches of mercury vacuum (Hg) are shown on the same dial. If the low side pressure drops into a vacuum a reading can be taken from 0 to 30 inches Hg. The pressure reading is usually from 0 to 60 psi. Some dials will show a normal area reading (7 to 30 psi) painted on the dial.

        (2) A high side (high pressure) pressure gauge shows the pressure calibrated from 0 to 600 psi. However, some gauges may show a smaller number of pounds per square inch, but they should be graduated to at least 300 psi. The high side reading is between 185 and 205 psi at 95 degrees F. Temperature variation will cause the psi to vary.

        (3) The gauge manifold provides connections for the two gauges and three hoses. These hoses connect the gauge manifold to the air conditioning system. There are two shut-off valves at each end of the manifold. When opening and closing the valves, the following things can be accomplished:

            (a) Bleeding air or excess refrigerant from the unit.
            (b) Removing refrigerant before working on the system.
            (c) When pumping-down the system, removing air and moisture.
            (d) Refilling the system with refrigerant.

(4) The gauge and mainfold set uses hoses that usually have screw-on connections and are sealed with an internal O-ring; therefore, they must be tightened only with the fingers. The two outside hoses are connected to the system's service valves, whereas the center hose is used to remove refrigerant, air, and moisture from the system. It is also used to add refrigerant to the system.

b. The types of leak detectors include:

(1) Colored dye additive which is added to the refrigerant. Leak areas are colored while the system is operating.

(2) Liquid detergent is used to coat possible leak areas except the condenser coils and evaporator coils. Bubbles will appear if refrigerant is escaping.

(3) Propane torch is one of the most widely used leak detectors because of its ease of handling and the cost of operation. The blue torch flame changes to yellow then purplish blue when the flame comes in contact with the refrigerant. The fumes from the flame can be toxic when mixed with the refrigerant.

(4) Electronic leak detector is an expensive type of detector but is considered very sensitive to operate. Leaks may be found with this detector that cannot be located with other types.

c. Another important testing tool is the vacuum pump. It removes or evacuates air from the system until a vacuum is created.

Transparency No. 1

2. Procedure Used to Install Gauge and Manifold Set for Making Test and Adding Refrigerant

a. The following steps may be used for installation:

(1) Use the proper size of wrench to remove high and low pressure valve stem caps. Pliers may be used to remove plastic or aluminum caps. Note: Wear a face shield to protect the face against the refrigerant.

(2) Slowly remove the high and low pressure connector caps. Sometimes the refrigerant may be found leaking past the Schrader valve or valve seat.

(3) Install the service gauge hoses to connectors. The high side hose connects opposite the high pressure gauge and the low side hose opposite the low pressure gauge.

(4) Set the service valves in mid-position. This is usually accomplished by rotating the valve from backseat two turns. Most modern systems use a Schrader type valve which has eliminated the regular service valve. The manifold hand valve is cracked on high then low side for three seconds to bleed hose on each side. A 15 oz. refrigerant container connected to the center hose can be used for this purpose. This method requires loosening both high and low hoses at service valve by turning back two turns. Tighten hoses after bleeding.

(5) Operate engine at recommended rpm (range 1500-1900 rpm). Idle speed screw can be adjusted to maintain speed. Engine must be warmed up before performing any test. Set air conditioning controls to maximum cooling.

(6) After the testing set is in place, an operating inspection may be made. The first step can be the performance test which will show high and low side operating pressures. For example, the low pressure gauge may read 7 to 30 psi and the high pressure will read 150 to 270 psi and above. These pressure readings naturally depend on the ambient temperature (outside temperature). The air coming from the evaporator should be cold. Again, outside temperature and humidity affect the temperature of the discharged air from the evaporator. For example, if the ambient temperature is 80 degrees F. and the relative humidity 50 percent, the air duct temperature will be about 41 degrees F. If the ambient temperature is 90 degrees F., and the relative humidity 60, the air duct temperature will be about 48 degrees F.

(7) Other performance testing procedures are:

(a) Examine the low side for frosting or sweating by feeling and looking at the lines from the evaporator to the compressor.
(b) Check the high pressure side by feeling system parts for the degree of heat.
(c) Set idle speed to regular operating rpm.
(d) Seat service valves by turning counterclockwise, then remove hoses from valves and replace caps.

Transparency No. 2

3. Detecting Leaks By Using a Propane Torch Leak Detector

a. Before a leak detector can be used, the system must be operative and be partially charged with refrigerant. The system must be operated long enough to build up pressure in the high side before testing for leaks. After the pressure equalizes between the high and low side, the low side is ready for testing. No leak tests are made with the engine and system in operation.

b. Procedure for making the test is as follows:

   (1) Light the flame and heat the copper element to a cherry red. Adjust the flame so the tip will be just below the center element. It should be almost colorless or a pale blue.

   (2) Move the end of the search hose along the bottom of each joint. Refrigerant weighs more than air; therefore, it moves downward from leaking joints. A yellow flame means a small amount of liquid is leaking from the joint. A purplish-blue flame means a large amount of refrigerant is escaping. It is a good practice to blow away all vapors from the system before making the test. The flame and refrigerant can form a dangerous gas (phosgene); so the fumes must not be inhaled.

Transparencies Nos. 2 and 3

4. Evacuating A System

a. To evacuate (removal of air and moisture) a system requires the use of a vacuum pump. A system's components can be severely damaged if moisture laden air is not removed. Air is removed until a vacuum is created by the vacuum pump.

b. Procedure for removing air is as follows:

   (1) Connect manifold gauge set to the system compressor and connect the center hose to the vacuum pump. On some setups a refrigerant-12 tank will be connected to the center hose between a shut-off valve and the manifold. All valves must be closed when making the connection.

   (2) If compressor service valves are used, turn to mid-position. At this point open the high and low pressure gauge valves. If there is a vacuum pump shut-off valve, it should be opened slowly to prevent oil being drawn from the system when the pump is started.

   (3) Start the pump and operate for about 30 minutes and at the same time

observe the compound (low pressure) gauge as the gauge reading moves down into the vacuum scale. At sea level the reading should be 28-29 1/2 inches Hg in not more than five minutes of operation. One inch is subtracted from the reading for each 1000 feet rise in elevation.

(4) Close valves on gauge manifold testing unit and turn off the vacuum pump.

(5) Check the vacuum on the compound gauge. If the reading does not rise faster than 1 inch Hg each 4 or 5 minutes, the system is holding the vacuum. If the reading rises faster than 1 inch Hg in 4 or 5 minutes then the vacuum pump must be used again. The system is usually ready for charging after this step.

5. Charging the System

a. After leak testing and evacuation, the system can be charged. In some instances it may be necessary to remove the air, fill with a partial charge, then leak test and evacuate the system again before making the final charge. Machinery operators that have a small amount of charging and testing equipment may use 15-ounce containers instead of a charging cylinder which is part of a portable charging station. Regardless of the type of refrigerant container used, the general procedure is the same for recharging. The procedure for charging a cooling system is as follows:

(1) After the hoses and gauges are properly connected to the compressor unit, connect dispensing valve to container of refrigerant. Close shut-off valve attached to container and use valve mechanism to pierce can.

(2) Connect the charging hose to the dispensing valve on the container and loosen it a turn or two where it connects to the manifold. Remove air from the charging hose by barely opening the shut-off valve. Retighten hose at manifold and close the shut-off valve.

(3) Begin charging the system by first opening the high side gauge valve, then open the dispensing shut-off valve. Turn bottom of can up so that refrigerant will enter the high side. Avoid over filling the system.

(4) Complete the charging of the entire system by closing the gauge valve and operating the engine to the given rpm (1500-1900 rpm). Set the controls on the unit for maximum cooling and open the low pressure gauge valve so that refrigerant can be drawn into the system. Continue to observe coolant in sight glass until bubbles no longer appear. In some systems a noise is present in the expansion valve until the system is charged. Excessive pressure on the low side may indicate over charging or air in the system.

(5) After the system has been charged, adjust the controls so that the cooling system will operate efficiently and continue performance testing the unit.

b. The cooling system may be charged by using a charging station. This type of charging equipment is found in large service and repair shops, and is either portable or stationary. A station is usually equipped with a vacuum pump, charging cylinder, leak detector, oil injection cylinder, high and low gauges, and hoses. When using this method for recharging a system, it is not necessary to operate the compressor, due to the system being pumped down properly and refrigerant allowed to flow as a gas from the heated cylinder.

6. Other Inspections and Tests

a. The volumetric compressor test is used to determine whether or not the compressor should be replaced due to worn or malfunctioning parts.

b. The expansion valve can be bench tested for malfunctions by connecting the low and high hoses to the valve and using refrigerant in a similar manner as charging the system (connected to the center hose). Usually a partial blockage in the screen, excessive moisture, or internal icing indicates a defective valve.

c. Oil should be checked in reciprocating piston compressors when adding or replacing refrigerant. Oil circulates in the system to lubricate the compressor and expansion valve. An axial piston compressor has no dipstick to accurately determine the oil level; therefore, oil is added by removing compressor.

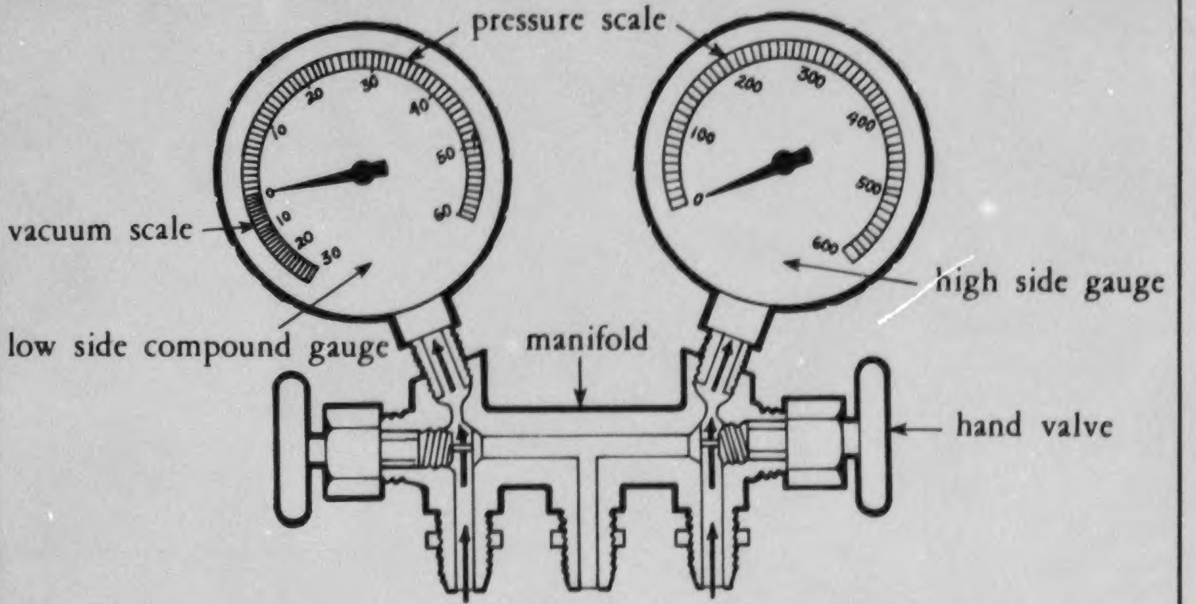
References:

1. Stockel, Martin W., Auto Service and Repair, The Goodheart - Willcox Company, Inc., South Holland, Illinois, 1969

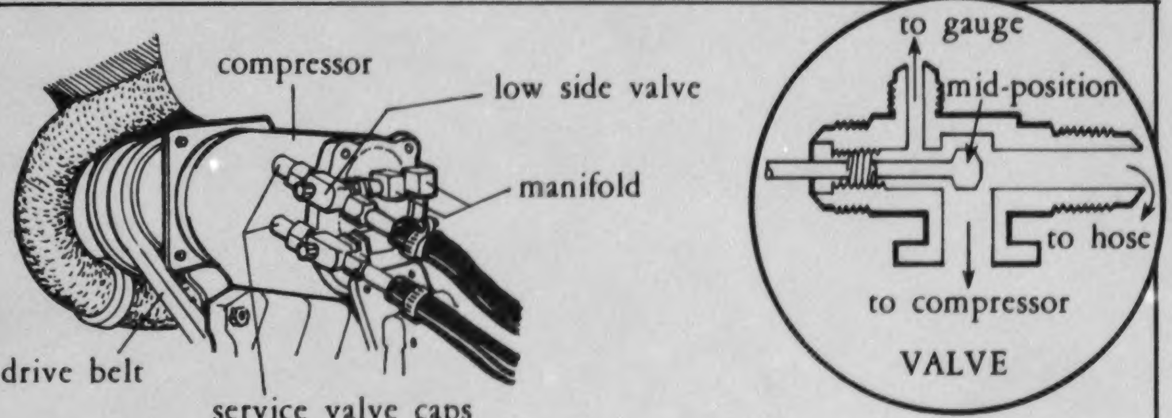
2. "Fundamentals of Service - Air Conditioning", Deere and Company, Moline, Illinois, 1970

3. "Fundamentals of Machine Operation - Preventive Maintenance", Deere and Company, Moline, Illinois, 1973

SERVICING COOLING SYSTEM


pressure scale
vacuum scale
low side compound gauge
manifold
hand valve
high side gauge
10
20
30
40
50
60
0
10
20
30
0
100
200
300
400
500
600

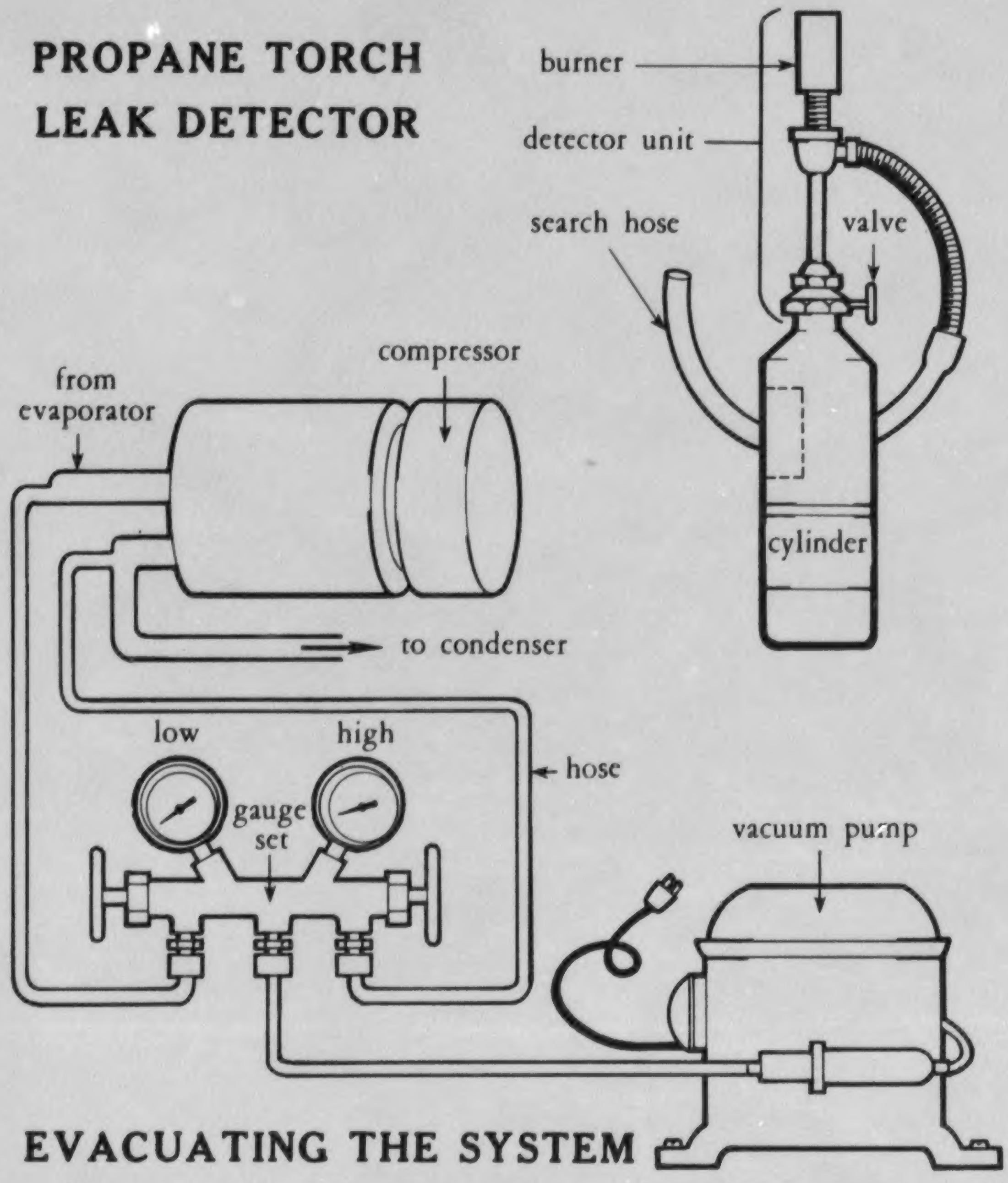
GAUGE SET


compressor
low side valve
manifold
drive belt
service valve caps
to gauge
mid-position
to hose
to compressor
VALVE

COMPRESSOR SERVICE VALVES

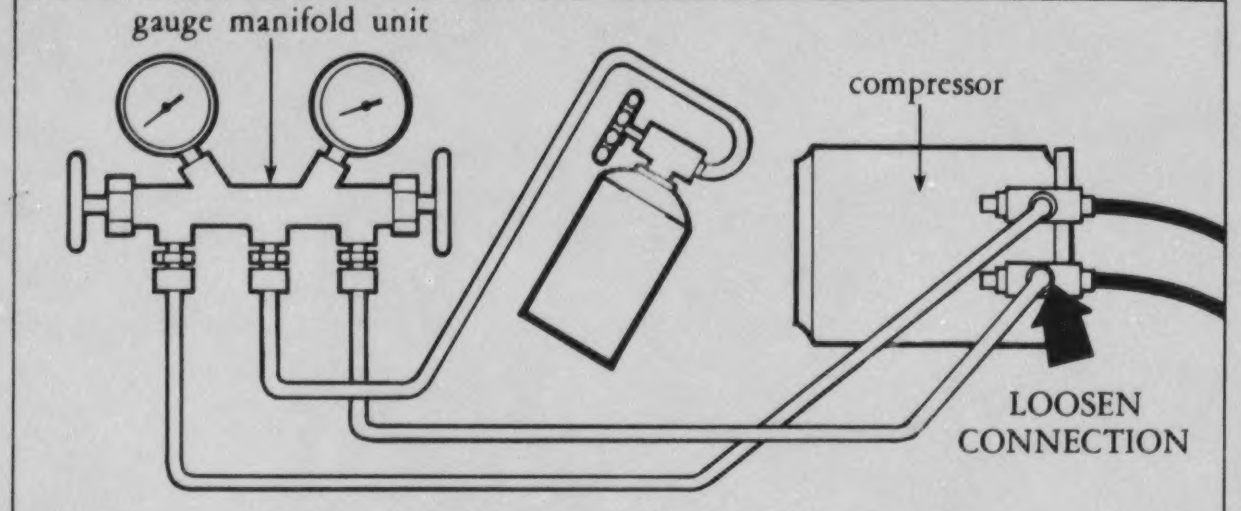
SERVICING COOLING SYSTEM

PROPANE TORCH LEAK DETECTOR

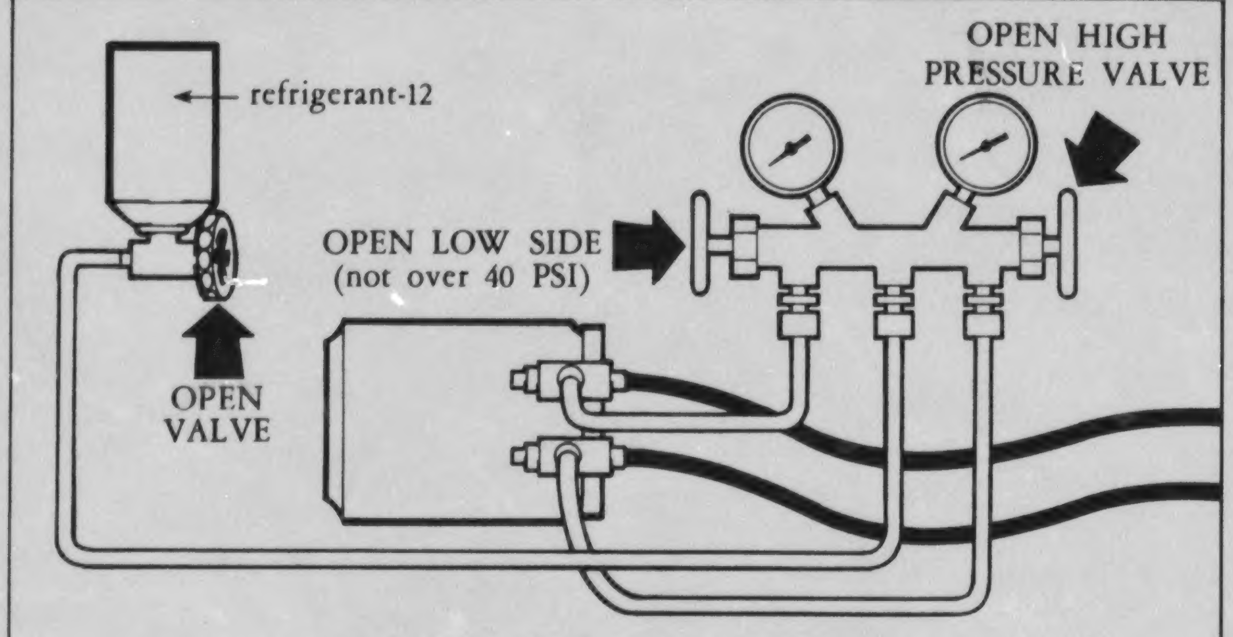

burner
detector unit
search hose
valve
cylinder
compressor
from evaporator
to condenser
low
high
gauge set
hose
vacuum pump

EVACUATING THE SYSTEM

SERVICING COOLING SYSTEM


gauge manifold unit
compressor
LOOSEN CONNECTION

REMOVING AIR FROM LINES


OPEN HIGH PRESSURE VALVE
refrigerant-12
OPEN LOW SIDE (not over 40 PSI)
OPEN VALVE

CHARGING THE SYSTEM

GENERAL AGRICULTURAL MECHANICS

Unit H: General Servicing

Topic 1: Servicing the Clutch

Suggested Procedures and Activities: Teaching aids such as a pressure plate assembly and two small disks mounted on a wood or metal shaft will be helpful when explaining the operation and parts of a clutch.

1. The Purpose of the Clutch

The major purpose of the clutch is to connect the engine with the transmission or disconnect the engine from the transmission. When the engine is disconnected from the remaining parts of the power train, the engine can be run while the machine is stopped.

The clutch is commonly recognized as the first part of the power train. When it is engaged with the engine flywheel, power is transferred to the transmission. This system of power transfer allows a load to be applied.

2. How the Clutch Functions

Transparency No. 1

a. The clutch uses friction to transmit power to the machine. The friction is caused by touching two separate surfaces together. These surfaces are made of steel and asbestos or some other material that will withstand heat and resist wear caused mainly by friction.

b. If two disks are mounted on two separate shafts opposite each other, one may rotate while the other remains motionless; that is, if the disks do not touch each other. But, as soon as the two disks come in contact with each other, both shafts will turn as a single unit. A disk clutch operates by this principle, two rough surfaces touching each other.

3. Types of Clutches

a. Disk Clutches - These clutches are classified as multiple and single disk types. The two types of multiple disk clutches are the oil bath and dry type.

(1) Oil Bath Clutch - The oil bath clutch is referred to as the wet clutch. This type of clutch is either mechanically or hydraulically operated. The increase in power transmitted is caused by the force exerted on the rear clutch plate. The disk plates are made so that the facings of the steel driving plates will join the bronze driven plates without slipping in an oil bath or spray.

Transparency No. 2

(2) Dry Type Clutch - The friction facing is molded to both sides of the driven disk, and the pressure plate is bolted to the flywheel. The driven plate is splined to the transmission input shaft. When the clutch pedal is depressed, the clutch release bearing is pushed forward against the release levers on the pressure plate, releasing the pressure that holds the plate against the face of the flywheel. This action is known as disengaging the clutch.

To engage the clutch the clutch pedal must be released. This action causes the clutch release bearings to move away from the pressure plate levers and allows the springs of the pressure plate to push the clutch disk against the flywheel. Power is then connected between the engine and the transmission.

Torque is transmitted by two or more plates coming together in this type of clutch system.

Transparency No. 2

b. Plate Clutches - Plate type clutches are made up of two driving parts and a plate which is clamped between the driving parts. The flywheel pressure plate and, on some tractors, the intermediate plate are the driving parts. The clutch disks are the driven parts. The intermediate plate is used in clutches with two disks. This type of clutch functions in about the same way as the disk type clutch.

(1) To engage the clutch the clutch pedal is released. This action moves the clutch release bearings away from the release levers in the clutch units, forcing the springs to exert pressure on the plate and holding the disk against the engine flywheel.

(2) To disengage this clutch, the pedal is pushed forward to push the release bearing against the release levers, causing them to pivot. This movement causes the plate to move away from the disk. The driving parts are free to rotate without rotating the disk.

There are two types of disks used in plate-type clutch units - flexible and rigid.

Flexible Clutch Disk - This disk has torsional damper springs located near the hub. The springs help absorb power impulses from the engine, reducing shock that is transmitted to the gears. The lining material in the disk is asbestos and woven wire. The linings are attached by bonding or riveting.

Rigid Clutch Disk - This rigid disk is fastened to a spline or hub. It is also called a solid clutch disk.

Transparency No. 3

c. Band Clutch - Torque is transmitted by this type of clutch as a band or belt is tightened around a moving part. When the band is tightened around the rotating part (flywheel), the two parts rotate as a single unit, producing torque.

The band-type clutch is used mainly on stationary equipment. This type of clutch system is considered to be large and bulky in comparison to the disk type system.

Transparency No. 3

d. Expanding Clutches - The two types of expanding clutches are:

(1) Mechanical - This clutch has shoes that are forced against the inner walls of the inner part (drum) by pushing the release bearing forward on release of the clutch pedal. The clutch is disengaged by moving the release bearing back, which takes the pressure off the pivot links.

(2) Centrifugal - The centrifugal type clutch consists of inner and outer parts, shoes, and vanes. The vanes are located around the hub. The shoes move outward and contact the outer clutch part as the inner part rotates. The shoes are partially held by the vanes. The centrifugal force holds the shoes against the wall of the outer part. Both parts turn as one unit.

Transparency No. 4

e. Overrunning Clutch - In the roller type, the center hub turns and the rollers move out and wedge between the inner and outer parts. If the source of power is stopped or the rotation is reversed, the clutch will freewheel or overrun. Engagement is realized when the drive line operates at a higher speed than the driven line. The three basic types of overrunning clutches are: roller, cam, and spring. The cam clutch operates similarly to the roller clutch - sprags are wedged between the inner and outer parts of the clutch. Rotation in one direction causes the spring to tighten around the shaft and drive it. To disengage the spring type clutch, rotation is made in the opposite direction.

f. Magnetic Clutch - The two types of magnetic clutches are:

(1) Direct - The magnetic field draws the driven and driving plates together - clutch is engaged.

(2) Indirect - The magnetic fluid or magnetic power clutch uses a mixture of oil and iron particles or a dry lubricant mixture (graphite) and iron particles that form a solid mass when energized by a magnetic field. This solid mass locks together the driving and driven members. This type of clutch is used where excessive clutch use is necessary and where slippage is needed to cushion the load.

g. Cone Clutch - This clutch is shaped like a cone. Torque is transmitted when the two cone parts come together. A throw-out bearing moves on the driven shaft and forces the drive part forward. The clutch lining of the outer part is forced against the surface of the inner part, causing both to turn in the same direction. This type of clutch is used for auxiliary power systems.

h. Hydraulic and Pneumatic Clutches - These clutches are considered a new type of clutch for most tractors. They both function in about the same manner. Oil or air is forced into a chamber, forcing the drive and driven parts together.

Transparencies Nos. 2 and 5

4. Clutch Control

The major ways clutches are operated are:

a. Mechanically Operated - Mechanically operated clutches use linkage and springs to engage and disengage the clutch.

    (1) Standard Linkage - This is the most common mechanical clutch operating mechanism. With standard linkage, the movement of the clutch pedal is carried through linkage to clutch release bearings and then to the pressure plate.

    (2) Over-Center Linkage - The expanding shoe clutch is locked into place when the collar is moved beyond the center position and against the stop. The clutch is disengaged when the collar is moved away from the stop position and beyond on-center.

b. Hydraulically Operated - The clutch pedal is attached to a master cylinder, the master cylinder is attached to a slave cylinder, and the slave cylinder is connected to the release yoke lever. The master cylinder is actuated by the movement of the clutch pedal. The clutch release yoke lever is actuated by hydraulic pressure from the slave cylinder.

c. Electrically Operated - The direct-action clutch is operated by a switch. An actuated switch sends current through the coil, which causes a magnetic field to be set up. The clutch facing is drawn against the facing on the rotor. To collapse the magnetic field, the switch is operated again. This operation frees the face plate from the rotor and stops the power.

   The indirect—action clutch also contains a coil. The coil is located in the driving member. It contains an inner driven part, magnetizable metal, and dry lubricant (graphite). The metal particles are mixed with the lubricant to form the energized mass. The amount of current applied determines the amount of slippage or solid drive.

Transparencies Nos. 6 and 7

5. Servicing the Clutch

Before attempting to service the clutch, study the causes of clutch problems. For example, if the clutch slips, adjustment of free travel may correct the problem. On the other hand, if the clutch chatters, it may be necessary to remove the clutch and replace the disk or even replace the housing.

The following procedure may be used in servicing the clutch:

a. Disconnect the clutch linkage with care. A damaged shifter rod, release shaft, or carrier can cause the clutch to function improperly.

b. Mark the clutch cover and flywheel with a prick punch before removing the pressure plate cover. This will allow the pressure plate assembly to be replaced in the same position so that the balance of the assembly will be the same.

c. Loosen the clutch cover and pressure plate bolts a little at a time to avoid twisting and warping of the cover. The disk may be held in place by inserting an aligning arbor through the disk hub to the crankshaft pilot bearing. On a coil spring type assembly use a press to hold cover in place. Check the coil springs for proper tension.

d. Clean the flywheel face and pressure plate assembly thoroughly with a nonpetroleum base cleaner. The throw-out bearing is sealed; therefore, do not wash it in a solvent.

e. Use emery cloth or aluminum oxide paper to sand the friction side of the flywheel and the pressure plate. Sand across the surface. Sanding will remove carbon and break the glaze on the surface.

f. Replace or rebuild the pressure plate assembly if inspection shows excess warpage or wear. It is usually best to install a factory rebuilt unit, unless skill can be applied in rebuilding the unit. Proper tools and checking devices are necessary for rebuilding an assembly. All parts of the pressure plate assembly should be marked on disassembly so that they can be reassembled in the same position.

g. Reassemble the parts in the clutch cover and place it over the pressure plate without the coil springs. Check drive lug clearance between clutch cover lug openings. Also, check clutch level adjustment.

h. Assemble the clutch assembly and either mount it to the flywheel or a base assembly fixture. Adjust the release fingers to the proper distance by adjusting the adjusting nuts. At this point the clutch should be actuated several times to allow parts to seat.

i. Install new clutch pilot bushings or bearings. The bushings may be removed with a threaded tip puller and installed with a driving tool. If the bushing is staked, remove the stake marks before removing it. Also, clean out the bushing recess that is located in the end of the crankshaft. The open side of the pilot bearing faces up.

j. Install a new clutch disk with the correct side facing the flywheel. Use a clutch disk aligning tool to align the disk hub and hold it in place while the cover bolts are being inserted. Tighten each bolt evenly in order that the cover will fit properly against the flywheel. Torque the cover bolts to specifications.

k. In case the clutch assembly is equipped with a throw-out bearing, remove the old bearing and press a new bearing on the sleeve by use of a press or vise. Do not use a hammer to seat the bearing.

6. Service of Clutch Controls

a. Mechanical Controls - If the clutch fails to operate properly, the linkage may have worn bushings, damaged fasteners (cotter pins), broken springs, bent rods, and/or clutch free pedal play. Control adjustments are:

(1) Replace worn bushings, damaged fasteners, broken springs, and bent rods.

(2) Check for free travel. Free travel movement may vary from 1/2 inch to 2-1/2 inches. This is the distance a pedal can be depressed from its stationary position until it meets resistance. Adjustments may be made on the shift rod, the stud on the housing, release shaft, and at the base of the pedal.

(3) Adjust the over-center type clutch by loosening the lock pin that is located on the clutch housing and turning the collar to the right to compensate for wear. Replace the pin and the housing cover.

(4) To properly maintain a wet type clutch, check the oil for proper circulation, check oil seals for leaks, check the oil lines for cleanliness, and check the oil pump for capacity.

b. Hydraulic Controls - Servicing the hydraulic controls includes:

(1) Check the clutch pedal free travel and adjust according to specifications.

(2) Check seals for leaks, check for broken or bent lines, and check for leaking pistons.

(3) Bleed the lines after repair jobs. Add fluid to the reservoir after bleeding the lines.

(4) Set the clutch throw-out bearing by adjusting the slave cylinder rod.

References:

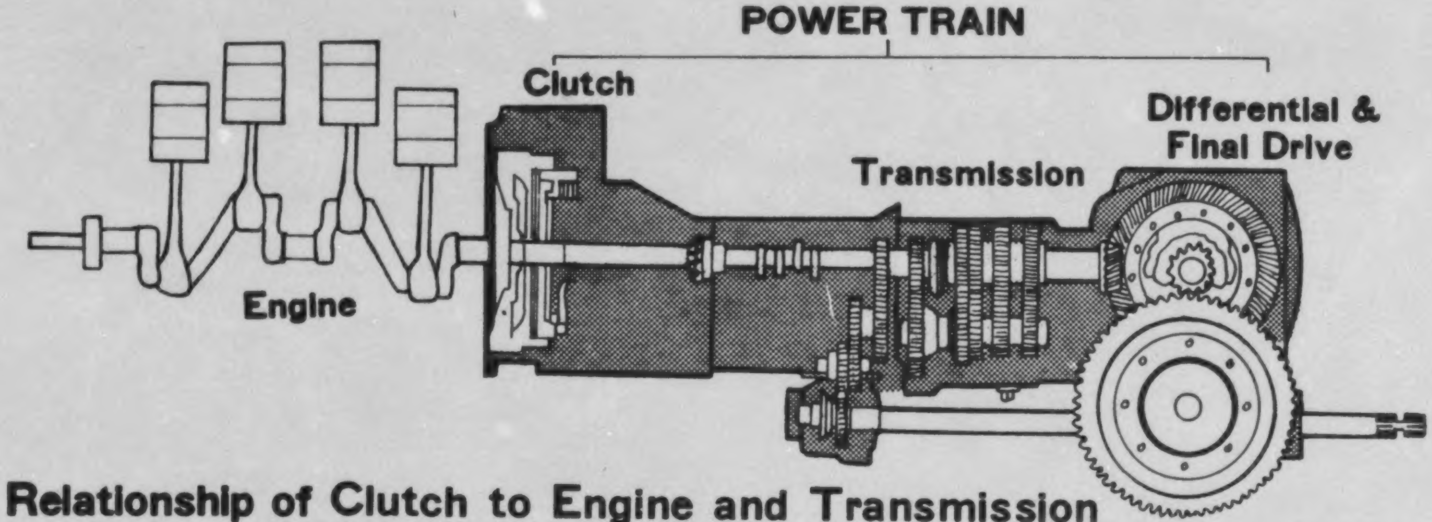
1. Stockel, Martin W., Auto Service and Repair, The Goodheart - Willcox Company, Inc., South Holland, Illinois, 1969

2. "Fundamentals of Service - Power Trains", Deere and Company, Moline, Illinois, 1973

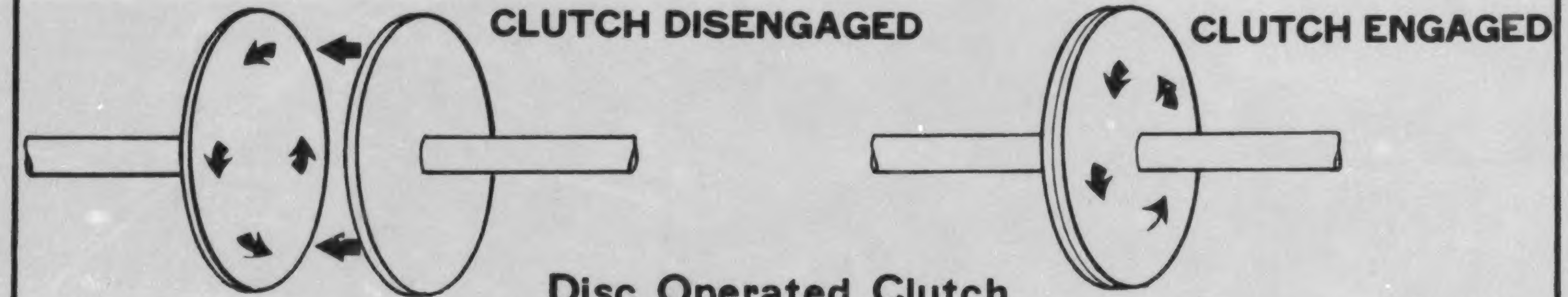
3. "Tractor Maintenance Principles and Procedures", American Association for Vocational Instructional Materials, Athens, Georgia, 1975

4. "Fundamentals of Machine Operation - Preventive Maintenance", Deere and Company, Moline, Illinois, 1973

CLUTCH OPERATION


POWER TRAIN
Clutch
Differential &
Final Drive
Transmission
Engine

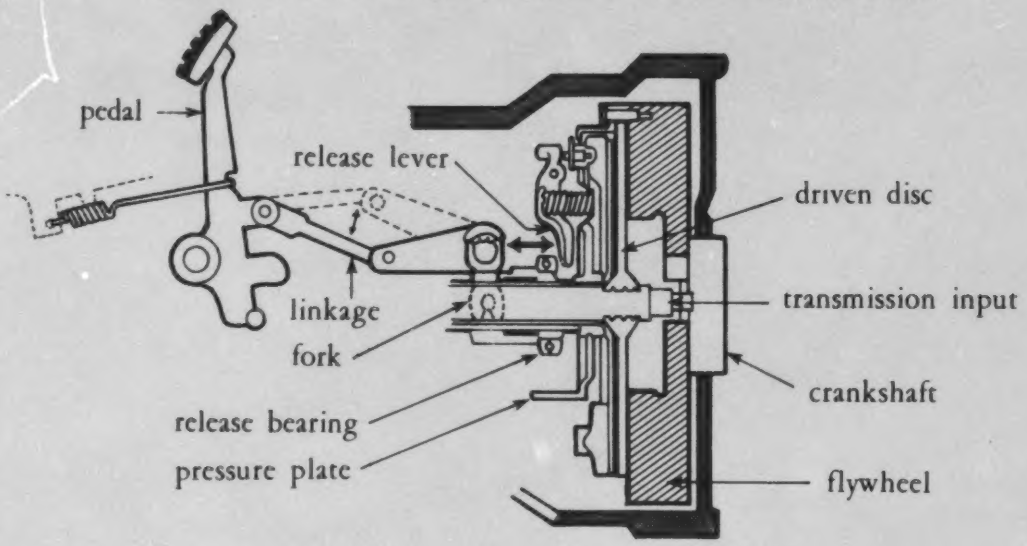
Relationship of Clutch to Engine and Transmission


CLUTCH DISENGAGED
CLUTCH ENGAGED

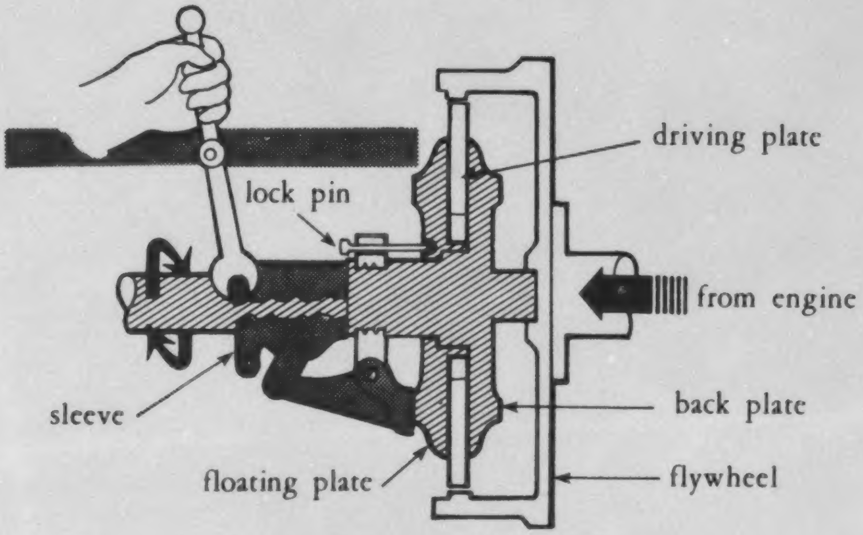
Disc Operated Clutch

DISC & PLATE CLUTCH ASSEMBLIES

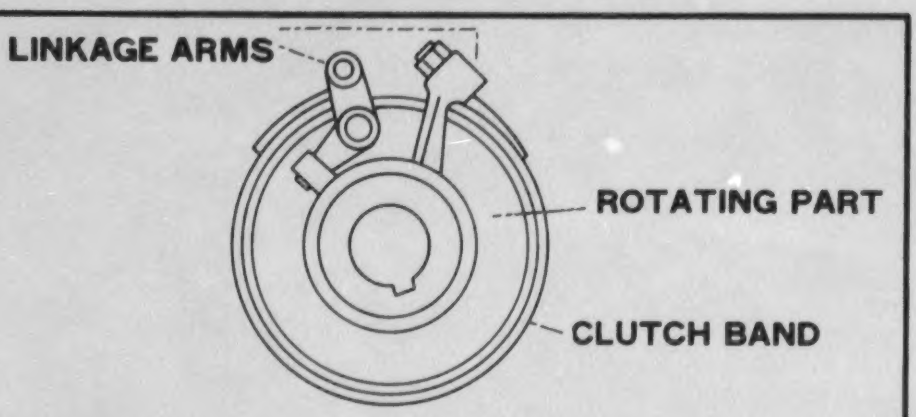
DRY TYPE DISC CLUTCH & LINKAGE


pedal
release lever
driven disc
linkage
transmission input
fork
crankshaft
release bearing
pressure plate
flywheel

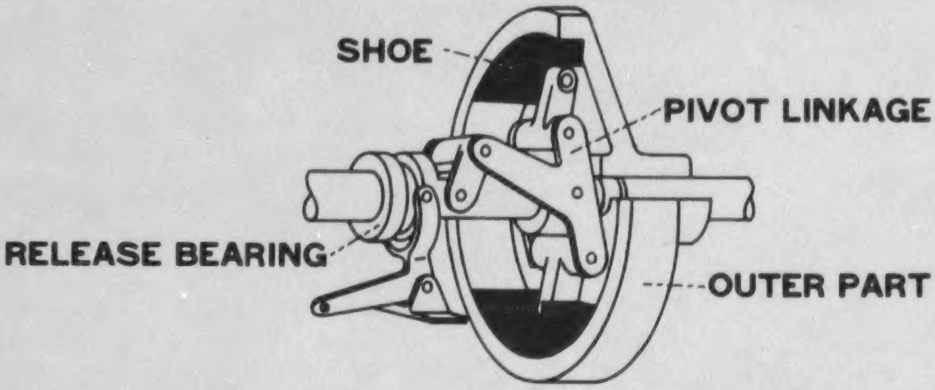
HAND OPERATED PLATE CLUTCH


driving plate
lock pin
from engine
sleeve
back plate
floating plate
flywheel

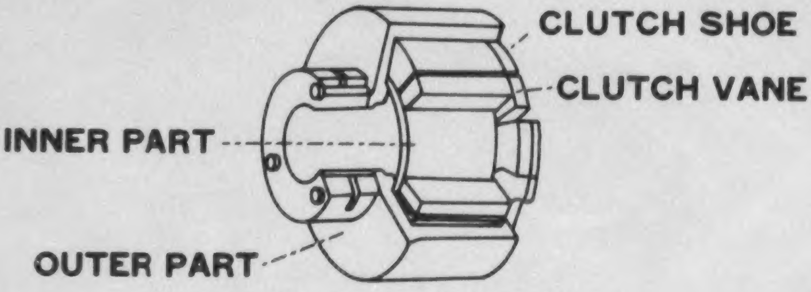
TYPES OF CLUTCHES


LINKAGE ARMS
ROTATING PART
CLUTCH BAND

BAND CLUTCH

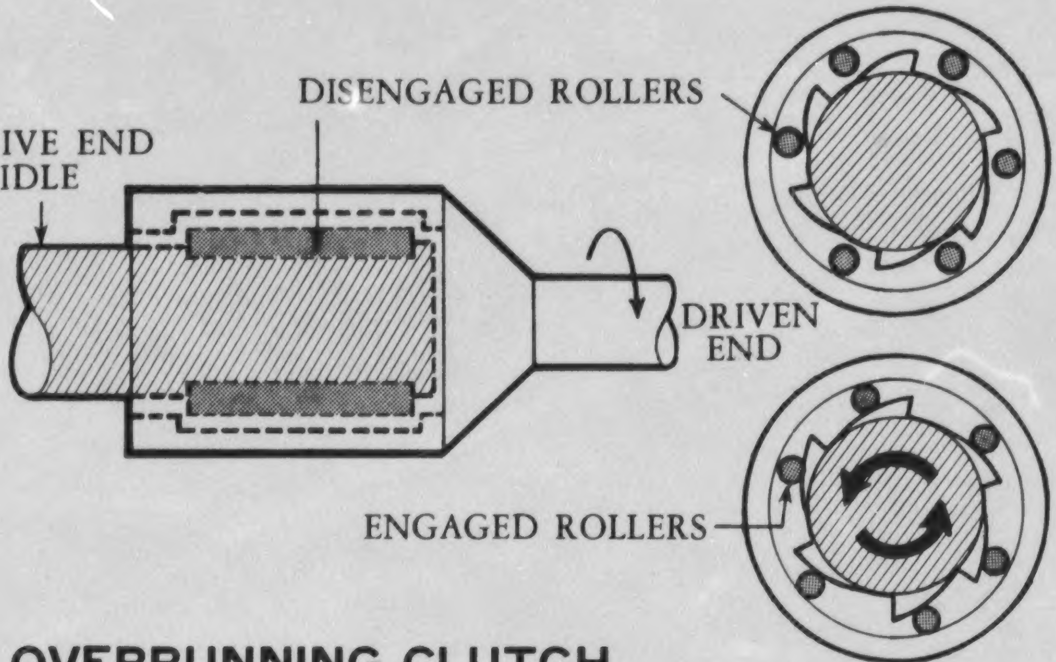

SHOE
PIVOT LINKAGE
RELEASE BEARING
OUTER PART

EXPANDING SHOE CLUTCH

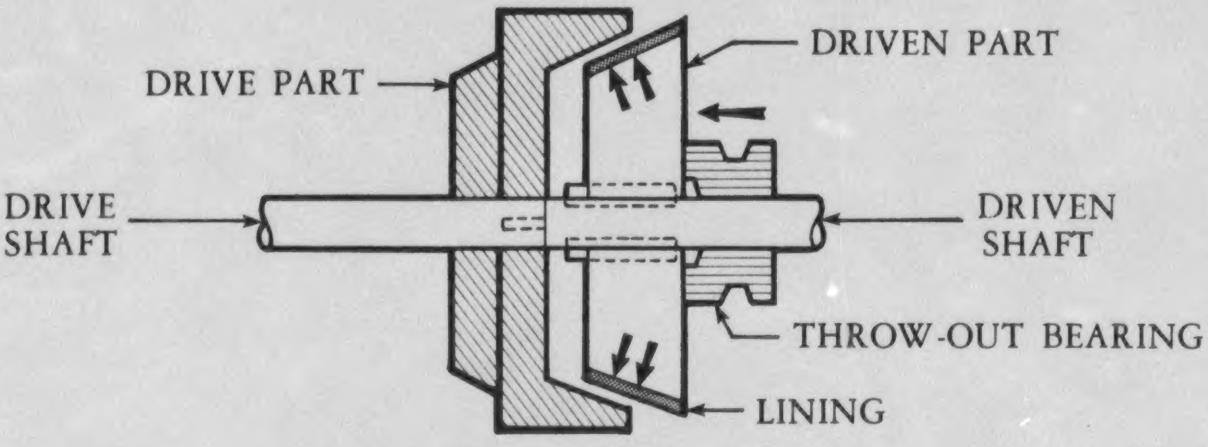

CLUTCH SHOE
CLUTCH VANE
INNER PART
OUTER PART

CENTRIFUGAL EXPANDING SHOE CLUTCH

TYPES OF CLUTCHES

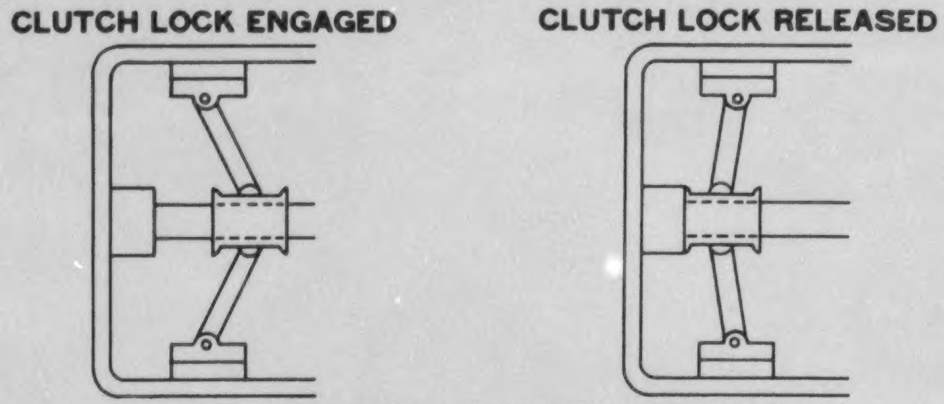

DISENGAGED ROLLERS
DRIVE END IDLE
DRIVEN END
ENGAGED ROLLERS

OVERRUNNING CLUTCH

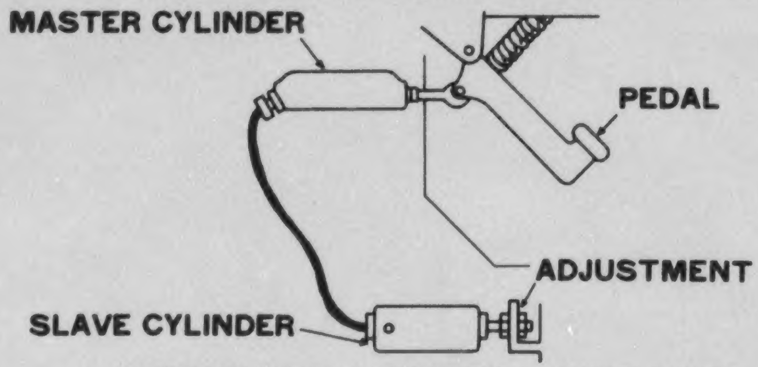

DRIVEN PART
DRIVE PART
DRIVE SHAFT
DRIVEN SHAFT
THROW-OUT BEARING
LINING

CONE CLUTCH

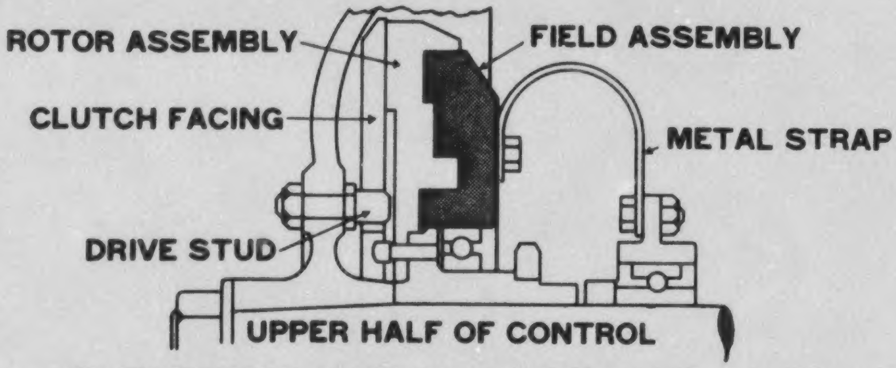
CLUTCH CONTROL


CLUTCH LOCK ENGAGED
CLUTCH LOCK RELEASED

OVER CENTER LOCKING LINKAGE

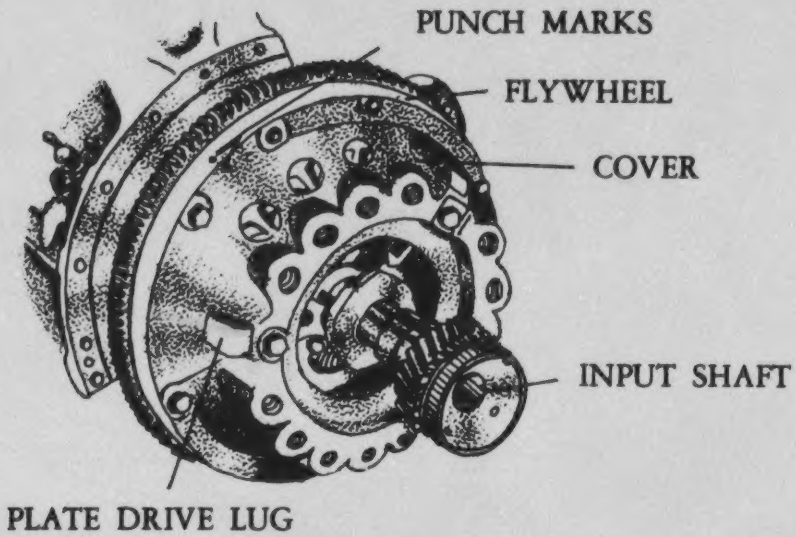

MASTER CYLINDER
PEDAL
ADJUSTMENT
SLAVE CYLINDER

HYDRAULIC CONTROL LINKAGE

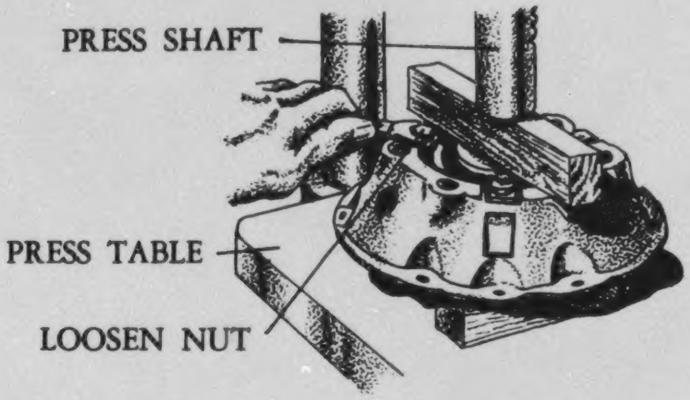

ROTOR ASSEMBLY
FIELD ASSEMBLY
CLUTCH FACING
METAL STRAP
DRIVE STUD
UPPER HALF OF CONTROL

ELECTRICAL DIRECT-ACTION CONTROL

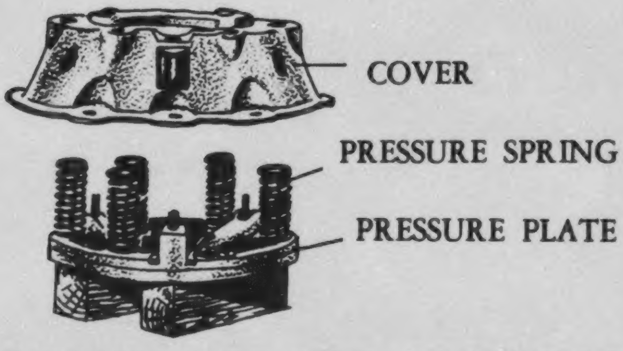
SERVICING THE CLUTCH


PUNCH MARKS
FLYWHEEL
COVER
INPUT SHAFT
PLATE DRIVE LUG

HOLD CLUTCH DISC IN POSITION

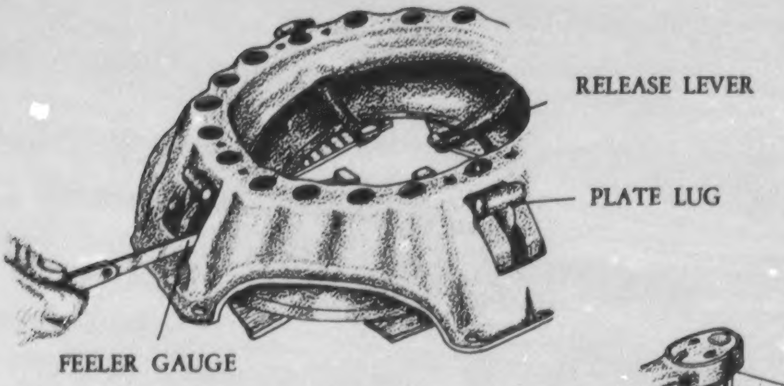

PRESS SHAFT
PRESS TABLE
LOOSEN NUT

USE DRILL PRESS TO REMOVE PRESSURE PLATE

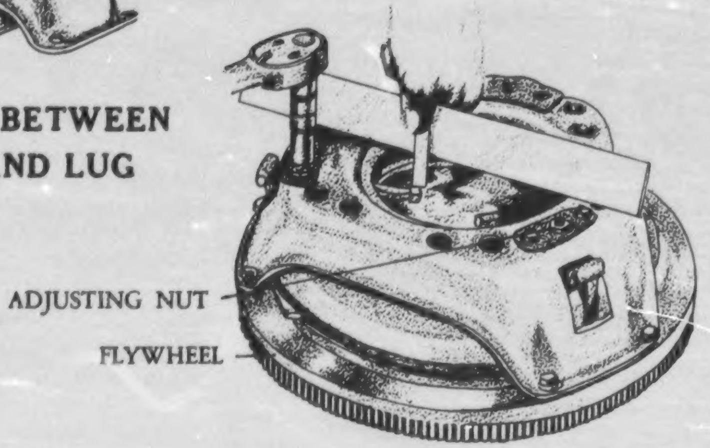

COVER
PRESSURE SPRING
PRESSURE PLATE

PRESSURE PLATE ASSEMBLY

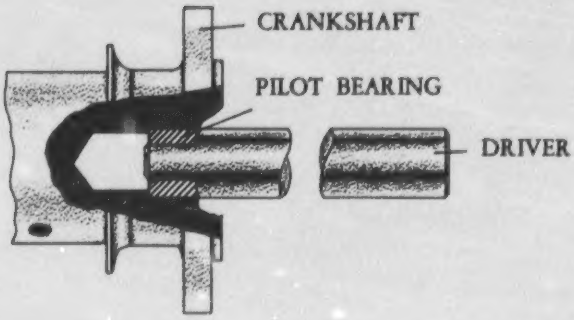
SERVICING THE CLUTCH


RELEASE LEVER
PLATE LUG
FEELER GAUGE

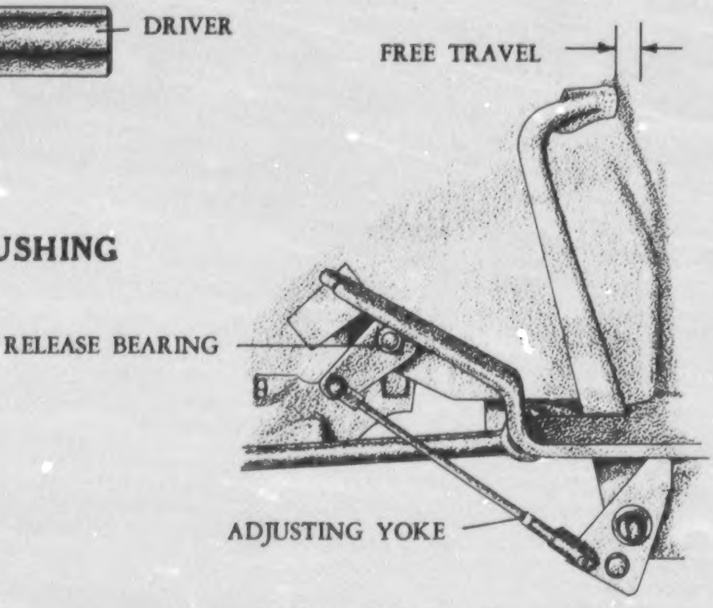
CHECK OPENING BETWEEN LUG OPENING AND LUG


ADJUSTING NUT
FLYWHEEL

CHECK RELEASE LEVER


CRANKSHAFT
PILOT BEARING
DRIVER

INSTALL PILOT BUSHING


FREE TRAVEL
RELEASE BEARING
ADJUSTING YOKE

CLUTCH ADJUSTMENTS

GENERAL AGRICULTURAL MECHANICS

Unit H: General Servicing

Topic 2: Servicing Tires and Wheels

Suggested Procedures and Activities: The use of a tire cross section or cut away and two or three tires to be examined during the classroom discussion will aid the student in determining tire structure, size, type, and tread.

1. Tire Construction

A cut away drawing helps to see the tire's vital parts.

a. Bead - The beads anchor the tire and rim together and are the foundation of the tire. All of the tire plies are tied to the strong bundle of wire, which is the bead, to prevent any change in shape or in the fit on the rim.

b. Body Plies - Layers of rubber-cushioned fabric or cord make up the body. The built-in strength in this part of the body holds in inflation and cushions shock. Each cord in every ply is surrounded by a resilient rubber compound. This cord may be rayon, nylon, cotton, polyester, or other materials. Nylon and rayon are the most popular, but polyester is coming into more common usage.

c. Ply Rating - All off-the-road tires are ply rated. The ply rating was used formerly to tell how many actual plies the tire had. Now it identifies a given tire with its recommended load when used in a specific type of service. As a comparison of two- and four-ply construction, to get the same strength, the two-ply cords are larger than the four-ply cords.

d. Bias Ply - In the normal tire, ply cords run from one tire bead to the other at an angle. Alternate plies run in opposite directions; the construction gives rigidity to the thread and sidewall.

e. Belted Bias Ply - The tire body is similar to the bias tire, but the body is surrounded by a semi-rigid belt. These belts are made up of very low angle cords which surround the tire body under the thread. These belts help give a more rigid sidewall and tread life.

f. Belted Radial Ply - The body cords run across the body from bend to bend almost at right angles. Fairly rigid cord belts surround the tire body under the tread. This construction gives better tread life and better tread support.

g. Wire-Reinforced Ply - On some large tires for earthmoving or other heavy equipment, a layer of wire is built in between the body and tread of the tire. This protective layer of wire keeps most cuts from penetrating into the tire cavity, keeps many tread cuts from growing, and tends to keep cuts closed so that sand and dirt will not enter and foster separation.

h. Sidewalls - The rubber covering on both sides of the body are called sidewalls. These are designed to flex and bend without cracking when used under normal and extreme sudden shock.

i. Tread - The tread is the part that contacts the road or ground. In most cases it must provide traction, resist cuts, and provide long wear.

j. Tubeless Inner Liner - This type of liner covers the inside form from bead to bead and serves as an air retainer.

k. Flaps - This type of protective item is used on tube type tires to protect the tube when it comes in contact with the wheel rim or tire beads.

Transparency No. 1

2. Tire Codes for the Different Types of Tires

Many types of tires are in use, especially in agriculture. To simplify things, a uniform code has been adopted by both the Tire and Rim Association and the Rubber Manufacturer's Association (RMA). The standard code is marked on the side of the tire, and it normally consists of a number plus a letter. As an example, in R-1, the letter R means it is a rear tractor tire. The number that follows tells the specific type of rear tractor tire.

Few tire makers will make all of the tire types for which codes have been established. All similar tires will be marked with the identical code. If you are not certain which tire is best for your particular purpose, consult a reputable tire dealer for advice. Some tire manufacturers will add the letter "O" after the industry code to show the tire has open tread design. They may also add the letter "C" to indicate a closed tread in the R-2 classification, and some types of tires may have an arrow showing the way the tire is to rotate.

There are many common terms used to classify farm equipment tires. Such terms as "first line", "second line", "top grade", and "100 level" are common terms used in the tire business when referring to tire quality.

The quality of the various makes of tires cannot be compared by using these terms. The "first line" tire of one company does not mean this tire is equal to the "first line" tire of another company. Also, different makes of tires that sell for about the same price may or may not be of the same quality.

3. Tire Sizes and Pressure

   a. If the tire marking on the sidewall of an off-the- road tire is 13.9/36, the number 13.9 means the width from one side to the other in inches on a mounted tire. The "36" is the rim diameter in inches. Older tires that have dual numbers such as 12.4 (mounted width) and 11-28 (11 by 28 inch rim) are being replaced as the older type rims are becoming obsolete.

   b. Some common tire sizes and pressure are follows:

Size	Ply	Pressure
	Front Tires	
All 4.00 sizes	4	20 lbs. - 44 lbs.
All 5.00 sizes	4	20 lbs. - 36 lbs.
All 5.50 & 6.00 sizes	4	20 lbs. - 32 lbs.
All 6.50 sizes	4	20 lbs. - 28 lbs.
All 7.50 sizes	4	20 lbs. - 24 lbs.
All 5.50 & 6.00 sizes	6	20 lbs. - 48 lbs.
All 6.50 sizes	6	20 lbs. - 44 lbs.
All 7.50 sizes	6	20 lbs. - 36 lbs.
	Rear Tires	
9 sizes - All 9.5	4	12 lbs. - 18 lbs.
10 sizes - All 11.2	4	12 lbs. - 16 lbs.
11 sizes - All 12.4	4	12 lbs. - 14 lbs.
12 sizes - All 13.6	4	14 lbs. - 14 lbs.
13.9	4	14 lbs. - 14 lbs.
10 sizes - All 11.2	6	12 lbs. - 26 lbs.
11 sizes - All 12.4	6	12 lbs. - 22 lbs.
12 sizes - All 13.6	6	14 lbs. - 20 lbs.
13.9	6	14 lbs. - 20 lbs.
13 sizes - All 14.9	6	14 lbs. - 18 lbs.
15.5	6	14 lbs. - 18 lbs.
14 sizes - All 16.9	6	16 lbs. - 16 lbs.
15 sizes - All 18.4	6	16 lbs. - 16 lbs.

Drive Wheels - Liquid Ballast

Size	Ply	Gallons Liquid
13.6-28	4	74
14.9-28	6	92
15.5-38	6	112
16.9-34	6	140
18.4-34	6	170

Transparency No. 2

4. Proper Tire Inflation and Tire Ballast

a. The proper inflation of tires is vitally important to their service life. Tires are made to work with a certain amount of sidewall bulge or deflection. The correct air pressure will insure proper traction, support of load, and flotation and will prevent excessive flexing which may cause overheating of the tire. The effects of improper inflation are as follows:

(1) Underinflation

Severe stress on sidewalls causing cracking
Excessive wearing of tread on each side of tire due to cupping
Excessive wear on shoulders caused by rim bruises
Twisted or broken valve stems
Powered equipment difficult to steer
Tire loose on rim causing it to slip

(2) Overinflation

Excessive wear especially on edge of tread bars
Excessive wear in center of tire
Possible fabric damage if tire hits sharp object
Tire slips on certain surfaces easily
Tread fails to clean when traveling in certain type of soil
Equipment ride is rough

b. Proper tire inflation is necessary at all times and especially when a machine is being continuously used; therefore, it is important to have an accurate pressure gauge. There are high and low pressure type gauges. A high pressure gauge is usually not satisfactory for checking low pressure, since they are marked in 5-pound increments. Low pressure gauges are graduated in one-pound increments. Things to remember about tire pressure are:

(1) Always check tire pressure and inflate if necessary when the tires are cold. As the tires get hot from use, the air will expand and the pressure will increase.

(2) Never "bleed" pressure from a hot tire. The expanded air, when let out, will result in an underinflated cool tire. If the tire is quite overinflated due to heat, you should reduce the load or the speed or both.

(3) If a tire becomes low of pressure while in operation, adjust the pressure to that of other tires of the same size on the vehicle.

(4) Always use a liquid-type gauge when checking pressure in tires filled with liquid ballast. If possible, always check pressure with the valve stem at the bottom, wash gauge clean, and dry after use. If it is undesirable or impractical to have the valve stem at the bottom, have the stem at the top, and add about 1/2 pound of pressure to the gauge reading for every one foot height of liquid in the tire.

(5) Tractor and implement tires are used most of the time in off-road or field conditions where the low pressure tire will give proper tire to ground contact. When operating over hard surface roads low pressure will cause tire distortion and tread bars to squirm and wear excessively. If the tires are to be used excessively on hard surface roads, increase the pressure to manufacturer's recommendations to help prevent wear. When the machine is placed back under field conditions release some air pressure so the tire to ground contact will again be proper.

c. Tire ballast (substance added to give stability) is very important to the proper use of tires. Many machines are not heavy enough to give proper traction, and with added weight more tractive power can be exerted. However, too much added weight causes compaction of the soil and increases the rolling resistance of the machine. Proper weight will cause some slippage (10 to 15 percent), whereas too much weight eliminates slippage and results in sharp, distinct tiretracks in the soil. Actually the amount of ballast depends upon the following conditions:

(1) Soil Surface - Less weight is required on a firm surface than on a loose surface. Firm surface may be such as corn stubble or hay pasture, while loose surface is as a plowed field.

(2) Type of Implement - Some implements transfer more weight to the rear wheels than others. Towed implements need more traction tire ballast than integral or rear mounted (semi-integral) implements.

(3) Travel Speed - More weight is needed for slower speeds than for higher travel speeds.

(4) Tractor Horsepower Output - Less weight is required for 80 - horsepower than for 100 - horsepower engines. Less weight is also required for a machine not working under full load. Operating at 3/4 load requires 3/4 as much rear weight as the same machine operating at full load.

(5) Type of Tires - Usually oversized tires give better traction. A conservatively used tire (all types) will usually give better service than one used to capacity.

d. Some types of tire ballast:

(1) Cast Iron Weights - Cast iron weights are obtained from tractor manufacturers. Most wheel weights are 40 to 140 pounds. Some factories may install heavier weights as original equipment. General practice is to install liquid ballast and then add cast iron to specifications.

(2) Liquid Ballast - Liquid ballast is almost always water with calcium chloride added to prevent freezing. When installing liquid you will normally fill the tire to 75 percent or to valve level. This is recommended because:

(a) The air chamber is needed to retain the pneumatic principle.
(b) The water or liquid solution will not compress. If the tire is filled to 100 percent, it is unable to absorb any shock and has no bruise resistance.

With 75 percent ballast, there is not too much extra weight for light load operation.

(3) Dry Ballast - Dry ballast is used sometimes for weighting tires. Some dealers have the equipment to install the dry ballast. Some manufacturers are installing dry ballast at the factory; 87 or 95 percent is a normal fill of dry ballast.

Advantages of dry ballast:

(a) It will give 20 to 30 percent more traction with less tire wear.

(b) Dry ballast will reduce the inherent bounce of rubber tires and make for a smoother ride.
(c) There is no danger of freezing. The dry material is treated to resist moisture.

Dry ballast is furnished from the manufacturer in three weights: 10, 15, and 20 pounds per gallon. The 15-pound is recommended for 90 to 95 percent of all farm tractors, while 20-pound is recommended for heavy equipment.

Some disadvantages of dry ballast:

(a) It requires higher initial cost than other types.
(b) It requires outside servicing with special equipment.
(c) Loss of ballast will occur if there is tire, tube, or valve failure. Dry ballast is showing its potential, and some manufacturers are now recommending its use with their equipment.

Transparency No. 3

5. Wheel Rims

a. Tractor and Implement Rims - Tractor and implement rims are made in many shapes. Most implement and tractor rims use a tube with the tire, but some rims and tires are made to be operated without tubes.

There are three measurements used to determine rim size. They are: rim diameter, rim width, and rim flange height. The diameter and width of a rim is measured in inches. The height is identified by letters (H.I.). The flange will indicate a certain flange height. For example, an AK rim is 0.77 inches high.

Four types of tractor and implement rims are:

Wide base drop center rims
Double bevel drop center rims
Deep well drop center rims
Drop center rims for front wheels of tractor and implements

b. Service of Wheel Rims - If rims are properly cared for when the tractor is operating and not in use, there will be fewer service problems than on many other moving parts of the tractor. Rim service performed is as follows:

(1) If a flat tire should occur, the machine should be jacked up at once to protect the tire and wheel rim. Running a machine with a flat tire will not only damage the tire and tube, but it can do a great deal of damage to the rim. If, after repairing the tire and tube, you replace it on a poor or damaged rim, you are likely to encounter much more trouble.

(2) Check the rim for any dents or sharp places which could damage a tire. Rim flange and bead seats should be clean. Use a wire brush, coarse steel wool, or emery cloth to clean the rim.

(3) When installing the wheel rim on the implement, the wheel lugs should be tightened in the proper sequence. This will insure that the wheel is against the hub properly and that binding or bending will not take place.

6. Adjusting Toe-In on Wide Axle Tractors and Machines

a. Toe-in means that the front of front tires are slightly closer together than the back. The proper toe-in causes the machine to track in a straight line and actually reduces wear on the tires. It also causes the steering of a machine to be easier. If the wheels are set parallel they will toe-out. Toe-in should be checked periodically or before the machine is put into use at the beginning of the season. Other things to check regarding toe-in are when the machine becomes difficult to steer, when the wheel spacing is changed, when front parts are exchanged or repaired, and when hitting a hole or solid object with a front wheel.

b. Some steps that may be followed when determining the need and adjusting toe-in:

(1) Operate the machine on level ground before measuring wheel tread at both front and rear of wheel. Measurements should be made at hub level.

(2) Use the operator's manual for proper specifications. Most machines may show a toe-in from 1/8 to 3/8 inches less for the front than from the rear.

(3) Some machines may have a single tie rod. This type of machine may be adjusted by loosening the tie rod clamp or clamps and screwing in or out the tie rod end until the adjustment is properly made. Then the clamps are retightened.

(4) If the machine has a tie rod for each wheel, both tie rod ends must be adjusted. Turn each end after loosening the clamps so that both front wheels will have the same toe-in.

References:

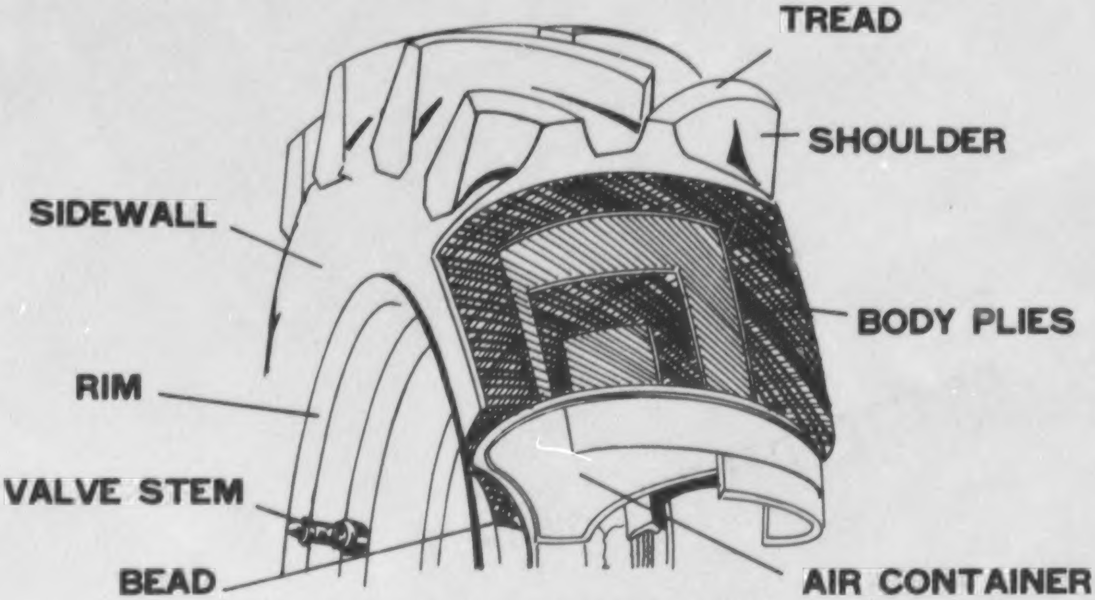
1. Stockel, Martin W., Auto Service and Repair, The Goodheart - Willcox Company, Inc., South Holland, Illinois, 1969
2. "Fundamentals of Machine Operation - Preventive Maintenance", Deere and Company, Moline, Illinois, 1973
3. "Fundamentals of Service - Tires and Tracks", Deere and Company, Moline, Illinois, 1970
4. "Tractor Maintenance, Principles and Procedures", American Association for Vocational Instructional Materials, Athens, Georgia, 1975

STANDARD INDUSTRY CODES

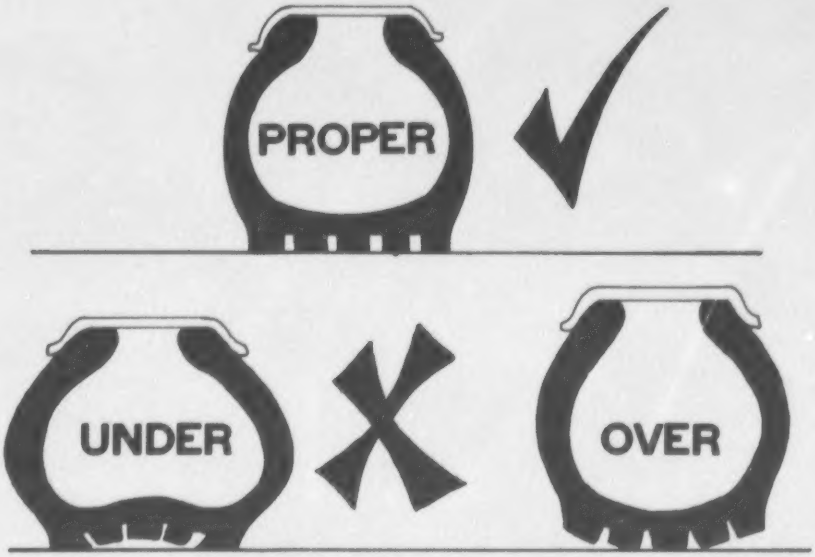
FOR TIRE TYPES *

TYPE OF TIRE	CODE
FRONT TRACTOR	
RICE TREAD	F-1
SINGLE RIB TREAD	F-2
DUAL RIB TREAD	F-2D
TRIPLE RIB TREAD	F-2T
INDUSTRIAL TREAD	F-3
DRIVE WHEEL TRACTOR (REAR)	
REAR WHEEL, REGULAR TREAD	R-1
CANE AND RICE, DEEP TREAD	R-2
SHALLOW, NON-DIRECTIONAL TREAD	R-3
INDUSTRIAL, INTERMEDIATE TREAD	R-4
IMPLEMENT	
RIB TREAD	I-1
TRACTION TREAD	I-3
PLOW TAIL WHEEL	I-4
SMOOTH TREAD	I-6
OFF-THE-ROAD TIRES (INDUSTRIAL)	
RIB	E-1
TRACTION	E-2
ROCK	E-3
ROCK, DEEP TREAD	E-4
ROCK, INTERMEDIATE	E-5
ROCK, MAXIMUM	E-6
FLOTATION	E-7

** ALSO INCLUDES SIMILAR TREAD FOR "G", "L", AND "ML" SERIES CODES.

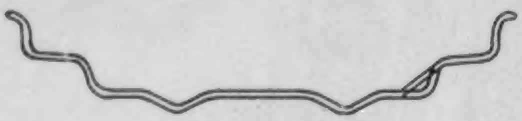

TREAD
SHOULDER
SIDEWALL
BODY PLIES
RIM
VALVE STEM
BEAD
AIR CONTAINER

PARTS OF A TIRE

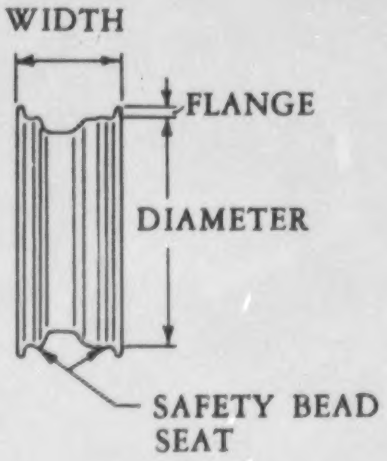

PROPER
UNDER
OVER

TIRE INFLATION

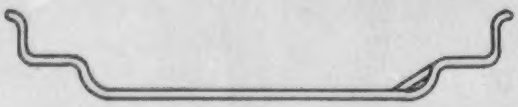
WHEEL RIMS



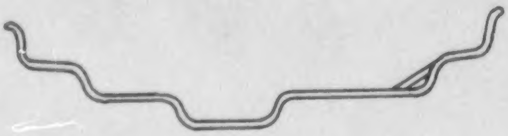
DOUBLE BEVEL RIM


WIDTH
FLANGE
DIAMETER
SAFETY BEAD SEAT

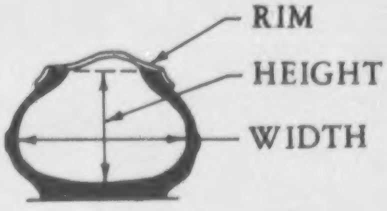
RIM MEASUREMENTS



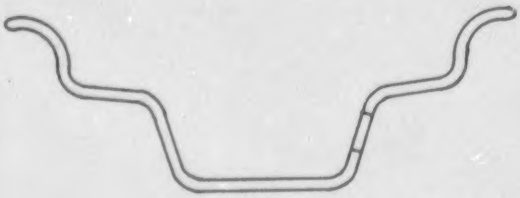
WIDE BASE RIM



DEEP WELL


RIM
HEIGHT
WIDTH

TIRE MEASUREMENTS



DROP CENTER
(TRACTOR FRONT
& IMPLEMENTS)

GENERAL AGRICULTURAL MECHANICS

Unit H: General Servicing

Topic 3: Servicing Brakes

Suggested Procedures and Activities: Parts of mechanical and hydraulic braking systems can be used as teaching aids in the classroom.

1. Purpose of Brakes on a Machine

The major purposes of brakes on a tractor are similar to the purposes of brakes on an automobile, with one exception, and that is turning the tractor. Brakes aid in maneuvering the tractor, and they serve as a safety device. The purposes are: slowing, stopping, and turning the tractor.

Most modern farm tractors can travel at a dangerous rate of speed if free of a load or pulling non-working equipment. Brakes are used to reduce the speed for making a turn or when approaching other traffic or objects. There are certain types of tractor jobs that require forward and reverse movement of the tractor and equipment. It is necessary that the tractor be stopped and started for this type of work. Stopping the movement of the machine, either for work or parking, may depend upon the frequent use of the braking system.

2. Factors Affecting the Use of Brakes

The speed of the tractor, the load it is pulling, and the surface it is traveling on are considered the chief factors that affect the use of the brakes. Other factors involved are:

a. Brake Conditions - Brakes that are severely worn or out of adjustment do not function properly.

b. Travel on Slopes - The tractor is assisted by gravity in making a stop if it is moving up a hill. If the tractor is traveling down a hill, gravity aids in its movement.

c. Tire Tread - Severely worn tires may require a different method of braking than new or good tires.

d. Pressure Applied on Brake - The force applied to the mechanical brake leverage may affect the function of the brake.

e. Braking Force of Engine - The engine is a braking force that is used any time the tractor is in motion. For example, the engine and low transmission gear may be used when traveling down a hill.

f. Turn - The number and degree of turns to be made in travel also affect the use of brakes.

Transparency No. 1

3. Some Common Types of Brakes

There are several kinds of brakes used on modern farm machines. The general functions of most brakes are the same, but the specific functions are different. The common types of brakes found on farm machines include:

a. Shoe Brake - Shoe brakes are considered an interval expanding type mechanism. The two brake shoes are forced against the brake drum when the brake pedal is depressed. When the brakes are not in use, springs hold the brake shoes off the drums. In this system of braking, the drums rotate around the brake shoes. The drums are mounted on either the differential or rear axle shaft.

b. Band Brake - In this kind of brake unit, the lined brake band is pulled around the outside of the rotating drum. The drum is mounted to the differential shaft or on the axle shaft. One end is attached to the tractor frame. When pressure is applied to the brake pedal, the band tightens around the drum and stops the rear wheel movement.

c. Disc Brake - The discs are mounted on either the differential shaft or the rear axle shaft; therefore, they rotate when the tractor is in motion. There are two actuating discs in this braking system; they do not rotate very far due to blocks in the brake housing. These discs are forced apart by three steel balls that move out of their slots when the discs rotate a short distance opposite each other. The two outside discs are forced against the housing braking surface by the inside discs.

d. Mechanical Disc and Band Combination Brakes - The function of the brake parts are similar to the disc and band brake. When pressure is applied to the brake pedal, the brake band tightens around the drum, and at the same time the disc is forced against the brake housing surface. This combination brake is attached either to the axle shaft or differential shaft.

Transparency No. 2

e. Hydraulic Disc Brake - The hydraulic brake system functions in the following manner:

The downward movement of the brake pedal closes the upper release valves and opens the lower pressure valve.

Hydraulic fluid pressure forces the piston brake shoes against the turning disc which is pressed against the stationary brake shoe. This slows or stops wheel movement. The lower valve closes and the upper valve opens when the brake pedal is released. This action permits the pressure to be released and the fluid to flow back into the cylinder. As the brake pistons move away from the brake disc, wheel movement is freed and the brake disc is free to rotate with the axle movement.

A hydraulic brake system consists of a mechanical type system with the addition of a master cylinder or fluid reservoir, hydraulic fluid lines, individual wheel cylinders at each braking point, and brake fluid in quantity to fill the entire system.

f. Electric Brake - The electric brake is very similar to and functionally the same as the components of all friction brakes. Instead of the mechanical linking or hydraulic pressure they use a electro-mechanical activating system operated from the machine's battery system. The electro-mechanical actuating mechanism is made up of a friction clutch and serves to generate the force which, multiplied by cams, presses the brake shoes to the drum. One plate of the clutch is the magnet and is mounted to the brake spider. This plate will rotate freely a limited number of degrees forward or rearward. The other plate of the clutch is the armature, which is secured to the brake drum and rotates with the wheel. When electric current is supplied to the magnet, it engages the clutch, and any movement causes the magnet to rotate to give braking power.

Transparencies Nos. 3 and 4

4. Servicing and/or Adjusting Brakes

a. Usually it is advisable to free both rear wheels so that they may be rotated. A hoist or jacks may be used to clear the rear wheels from the ground.

b. If both pedals are on one side, they are usually locked together. Unlatch the brakes, make adjustments on lock brake first, but not so tightly that it will not latch. Adjustments are usually made on different types of brakes in the following manner:

Disc or Band Brakes - Loosen jam nut and adjust pull rod. There may be a brake rod with an adjustment at the yoke. In this case, the lock nut is loosened and the yoke is turned on the rod. Some disc brakes are adjusted by side adjusting screws.

Internal Shoe Brakes - The adjusting slot cover is removed and the star wheel is turned with a screwdriver or special star wheel tool. Tighten until there is drag, and release until there is little or no drag.

External Shoe Brake - This brake is adjusted by turning the adjusting screw between the brake and the housing. Tighten until there is drag, and release until there is no drag.

c. The second brake should be adjusted in the same manner as the first brake. The same amount of free travel should appear in the second adjustment as in the first adjustment.

Usually a brake is adjusted by shortening the linkage between the brake and pedal or by making the star wheel adjusting screw longer. The brake is tightened until there is a certain amount of free travel on the brake pedal. The distance of pedal free travel is specified in the operator's manual.

d. The brakes are checked for equalization by practicing the following steps:

(1) Latch the two brakes together.

(2) Start the engine and start the wheels turning by shifting into third gear.

(3) Shift back into neutral and apply pressure to the brake pedal. Check the wheels to determine if they brake evenly.

(4) The last step is to lower the tractor to the ground and check the brake by driving the tractor in third gear.

e. Hydraulic Brake Adjustment - Hydraulic brakes have the same adjustments on the discs, shoes, and bands as do mechanical brakes, so adjustment should follow the manufacturer's suggestions.

A hydraulic brake system consists of a mechanical type of system with the addition of a master cylinder or fluid reservoir, hydraulic fluid lines, individual wheel cylinders at each braking point, and brake fluid in quantity to fill the entire system.

The bleeder valve found on the back side of the brake backing plate, when opened, allows all air to rush from the wheel cylinder. The following procedure is suggested:

Clean the dirt from master cylinder filler cap before removing.

Fill master cylinder with clean fluid to capacity.

With brake pedal depressed a full stroke, the bleeder valve should be opened three-quarters of a turn to allow air to leave that portion of the system.

Retighten bleeder valve and release pedal. (Retightening valve before releasing pedal prevents air from being drawn back into system.)

Repeat this step until only clean fluid runs from valve with no air bubbles.

Check master cylinder to keep full of fluid.

Retighten bleeder valve and move to next wheel.

Repeat the bleeding process until all wheel cylinders are free of air and machinery has adequate pedal height when completely depressed.

5. General Information About Brakes

Brakes should be checked and adjusted periodically. Well adjusted brakes may mean safer and more efficient use of the tractor and its equipment.

Farm tractor brakes are located on each rear wheel. If the brake pedals are on each side of the tractor, or both are located on one side and unlatched, the tractor can be turned sharply by braking the inside wheel.

Most farm tractors brakes are operated by foot pedals. But some tractors have hand brakes.

References:

1. Promersberger, William J., and others, Modern Farm Power, Prentice - Hall, Inc., Englewood Cliffs, New Jersey, 1971

2. Stockel, Martin W., Auto Service and Repair, The Goodheart - Willcox Company, Inc., South Holland, Illinois, 1969

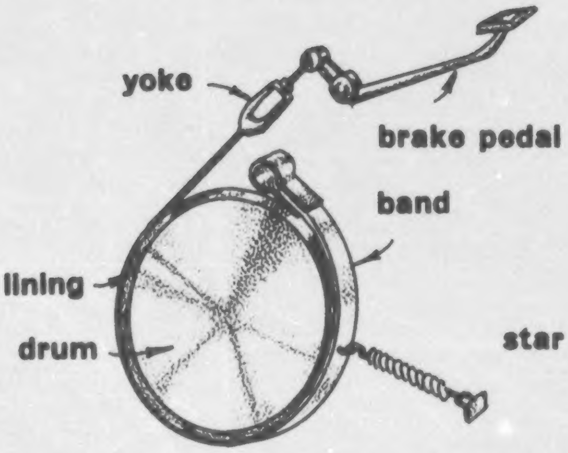
3. Stone Archie A., and Gulvin, Harold E., Machines for Power Farming, John Wiley and Sons, Inc., New York, New York, 1967

4. "Truck and Diesel Repair Manual", Motor, New York, New York, 1972

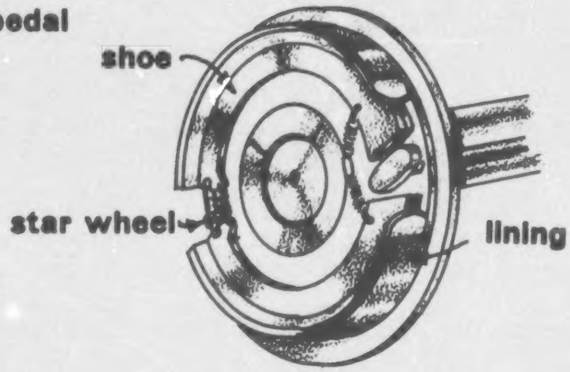
5. "Fundamentals of Machine Operation - Preventive Maintenance", Deere and Company, Moline, Illinois, 1973

6. "Tractor Maintenance, Principles and Procedures", American Association for Vocational Instructional Materials, Athens, Georgia, 1975

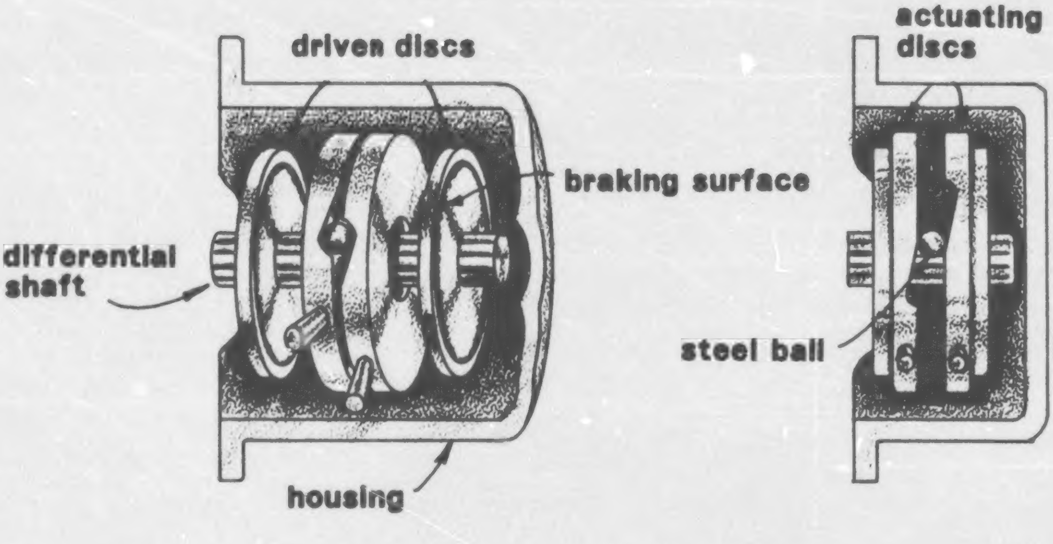
TRACTOR BRAKES


yoke
brake pedal
band
lining
drum

BAND BRAKE

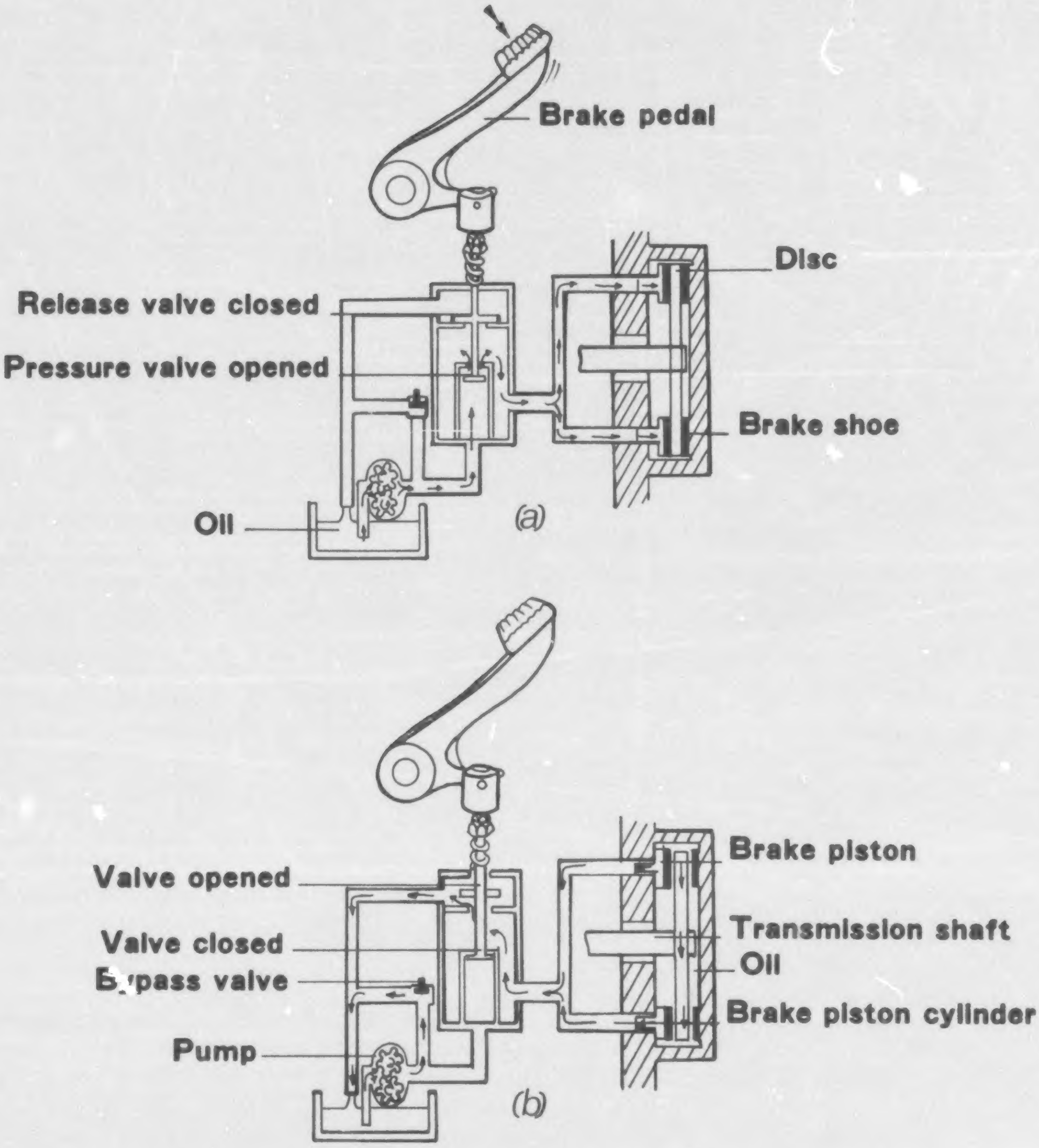

shoe
star wheel
lining

SHOE BRAKE


driven discs
braking surface
differential shaft
housing
actuating discs
steel ball

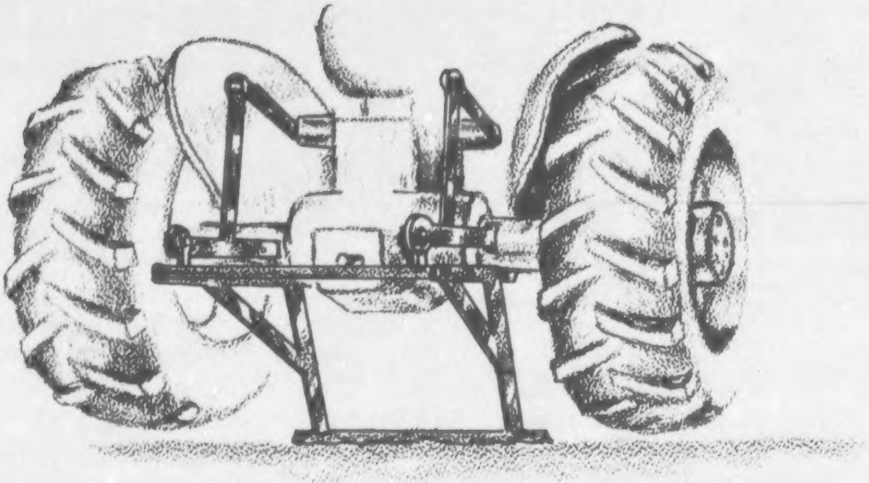
DISC BRAKE

TRACTOR BRAKES

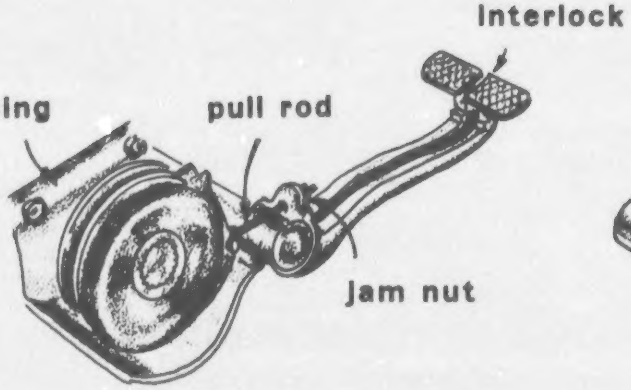

Brake pedal
Disc
Release valve closed
Pressure valve opened
Brake shoe
Oil
(a)
Brake piston
Valve opened
Transmission shaft
Valve closed
Oil
Bypass valve
Brake piston cylinder
Pump
(b)

OPERATION OF A HYDRAULIC BRAKE

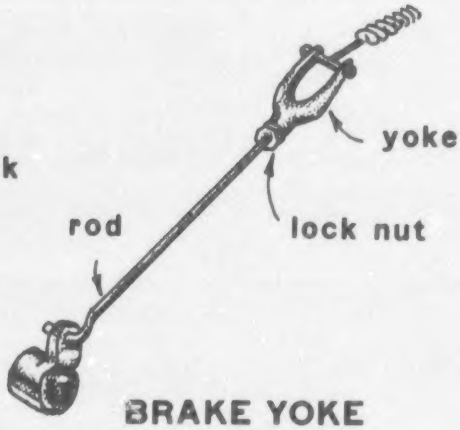
TRACTOR BRAKES



REAR WHEELS OFF GROUND

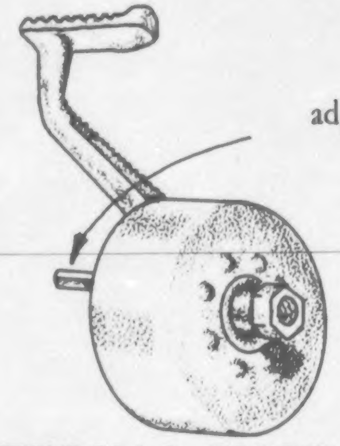

interlock
housing
pull rod
jam nut

DISC BRAKES & PEDALS


yoke
rod
lock nut

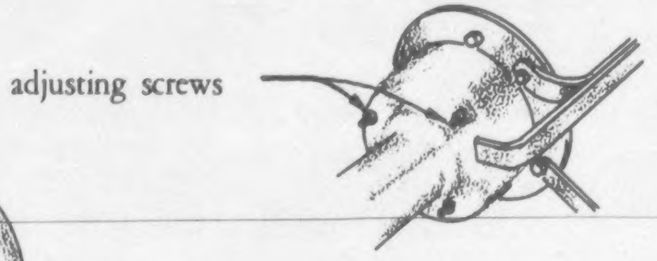
BRAKE YOKE ADJUSTMENT

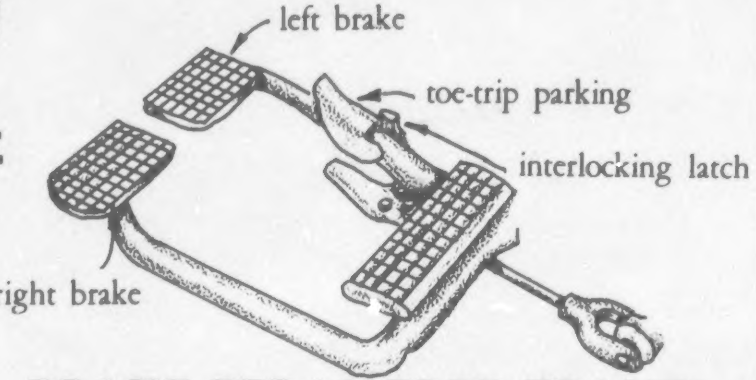
TRACTOR BRAKES



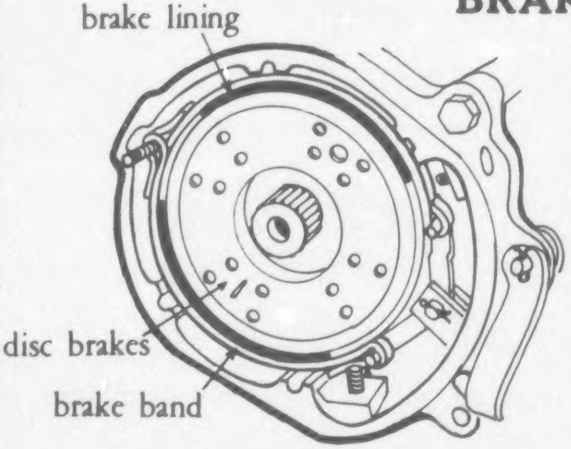
EXTERNAL SHOE BRAKE

DISC BRAKE

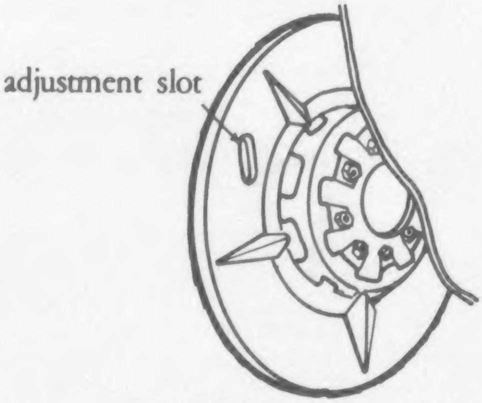

adjusting screws


left brake
toe-trip parking
interlocking latch
right brake

BRAKE PEDAL FREE TRAVEL


brake lining
disc brakes
brake band

COMBINATION BRAKE


adjustment slot

INTERNAL SHOE BRAKE

GENERAL AGRICULTURAL MECHANICS

Unit I: Painting Power Units and Farm Machinery

Topic 1: Cleaning and Painting Farm Machines

Suggested Procedures and Activities: Labels from paint containers, types of brushes, cleaning tools, safety equipment, and samples of paints and ingredients can be used in the classroom during the class discussion.

1. Importance of Painting

Paint protects metal and wood surfaces from corrosion and, in some cases, wear. It adds to the appearance of a machine; therefore, the value of the farm machine is partially maintained through a good painting program. Machines that are not properly housed during the season that they are not in use must be protected by paint.

Tractors and other types of farm equipment that are traded in on new equipment bring a higher value if the paint is in good condition. A well cared for surface may mean the entire machine is well cared for.

2. Selecting the Proper Paint

About two-thirds of the cost of painting is in the labor; therefore, it is advisable to select a lasting, good grade of paint in order to reduce the number of paint jobs. Good grades of paint contain the correct amount of ingredients. For example, a good paint may contain 60 percent pigment and up to 40 percent vehicle. Enamels contain 40 percent pigment and 60 percent vehicle. In areas where hydrogen fumes and mildew are a problem, the pigment should contain between 18 and 40 percent zinc oxide.

Metal paints should contain rust inhibitors such as red lead, metallic zinc, blue lead, or zinc chromate. Also, the primer coat should contain an inhibitor. This coat adheres directly to the metal surface; therefore, it prevents the metal from oxidizing. Ordinary paints do not contain an agent that prevents or limits rust. Regardless of the type of metal paint used, the directions on the label should be followed.

3. Importance of Cleaning the Surface to be Painted

Proper cleaning of the machine and its parts is one of the most important jobs that is performed while repairing farm machines. Improper cleaning usually means an improper overhaul or repair job. If the machine or any of its parts are to be painted, the paint will not adhere to greasy dirty surfaces. There are several different methods or techniques used to clean farm machines and machine parts. These techniques are:

a. Wire Brush and Scraper - Cooked on accumulation of oil on the exterior of engines and other parts must be cleaned with scrapers and power brushes. Power brushes are not used on soft parts. Wash part or parts in solvent after cleaning with brush and scraper.

b. Parts Washer - Used for washing small parts. Many cleaning solutions may be used in parts washers. Many cleaning solutions are dangerous and should be used with care.

Never use gasoline as a cleaning agent. Allow no smoking and place washer in a well ventilated area.

c. Hot Tank Cleaning - A strong alkaline compound is usually mixed with water and the solution heated from 180 to over 200 degrees F. The solution is used to clean large parts such as blocks, transmission cases, etc. Wash off thoroughly with water.

d. Steam Cleaning - There are many different steam cleaners on the market. It is important that the manufacturer's recommendation be followed when using this type of equipment. This is one of the best ways to remove most oil and dirt deposits. A solvent may be used to remove an oil film when using this cleaning method.

e. High-Pressure Spray Cleaning - This piece of equipment may use cold water under high pressure with cleaning compound injected. Some manufacturers have models with a heating coil so that water may be heated to about 160 degrees F. higher than the source.

f. Low-Pressure Spray Cleaning - In this method an air operated mixing gun is used. The cleaning solution is sprayed on and then the object being cleaned is either washed down with a water hose or the mixing gun.

g. Cold Soak Cleaning - Parts are placed in a basket or container and lowered into a cleaning solution. After a specified amount of time the parts are washed off with water and air dried.

h. Vapor Cleaning - Cleaning may be accomplished by heating a solution so that the vapors deposit on the parts. The solution is not flammable.

i. Sand Blast Cleaning - The sand blast is not used for cleaning parts but may be used for cleaning before painting.

j. Old Surface - Old surfaces are more difficult to prepare than new surfaces. Simple steps in preparing an old metal surface are:

(1) Use a mild caustic compound with steam or hot water to clean farm machinery. Kerosene and other cleaning solvents can be used if steam is not available. Compressed air, a putty knife, wire brush, emery cloth, steel wool, and a screwdriver are necessary items to remove paint from metal.

(2) If bolts are present, they should be tightened before paint is applied.

(3) All repair work on farm machinery should be completed before it is painted.

(4) A blow torch or a good liquid paint remover is the easiest way to clean farm machinery of old paint. This practice will require scraping the old paint off, sanding the surface, and applying a priming coat.

k. New Surface - New surfaces usually require less time to prepare than old ones. Steps in preparing wood and metal surfaces include:

(1) Smooth the surface if necessary with emery cloth or steel wool.

(2) Wipe the surface clean of all dust, moisture, grease, and other matter that may interfere with a good paint job.

(3) Use a good rust inhibiting primer.

(4) Line coating (galvanized metal) should be allowed to age before painting.

Transparency No. 1

4. Problems Encountered in Applying Paint

a. Paint Failures - There are six major causes for the failure of paint to give long protective coating. The causes are:

Blistering and Peeling - Blistering is caused by moisture collecting behind the paint, or on the surface at the time of painting. Almost all painting is done where the surface is dry.

Cracking and Scalding - Cracking is caused by the surface expanding and contracting. A high grade of paint will have a more elastic effect to prevent this paint failure.

Running and Sagging - Paint applied too thickly or a paint containing too much oil will run or sag. Also, a glossy surface may cause paint to sag. A glossy surface should be sandpapered before it is painted.

Wrinkling - Wrinkling is a common cause of paint failure. If the surface dries before the paint underneath dries, it will wrinkle. A drop in temperature, thick coat, or too much oil are some of the main causes of wrinkling. Wrinkles should be sanded out before repainting.

Checking - This failure in painting is the result of not mixing the proper proportions of thinner and oil and failing to allow paint to dry between coats. The fine hairlines that appear in checking are only in the outer coat.

Chalking - Surface that has been painted for a long period of time may have a tendency to chalk. The pigment will stick to anything it touches. Low grade paints chalk more easily than high grade paints.

b. How to Determine the Amount of Paint Needed - The amount of paint needed is estimated as follows:

The amount of paint required to cover a surface depends upon whether or not the surface is smooth or rough, the skill of the painter, and the type of material used to make up the surface. High grade paints may cover over 500 square feet for the first coat and over 600 for the succeeding coats.

Instead of using the square feet method for painting farm machines, an estimate of the amount of paint is made according to the type and size of the machine being painted.

5. Brush Painting

   a. Equipment and supplies needed are:

      Paintbrushes - 1 inch for small areas, 1-1/2 to 2 inch for average type areas and 3-1/2 to 4 inch for other larger surfaces. The best brushes are made of 100% hog bristles.
      Paint scraper
      Wire brush
      Putty knife
      Hammer, and wrenches
      Mixing bucket and paddle
      Ladders
      Putty and wood filler
      Sandpaper, emery cloth, and rags
      Thinner and solvents for cleaning

   b. Steps to follow when applying paint are:

      (1) Paint is mixed by pouring the thin material off the pigment, stirring the pigment with a paddle, adding the thin material to pigment, and continuing to stir until the paint is mixed.

      (2) Hold the paint brush by placing the thumb over the small part of the brush handle with the fingers resting on the brush ferrule (large part of brush).

      (3) Dip about one-third the length of the bristles into the paint.

      (4) Remove the excess paint from the brush by wiping one side against the paint bucket.

      (5) Apply paint to a surface by bringing the brush against it very lightly, then make long sweeping strokes in the same direction to form a thin uniform film. The brush should be lifted gradually at both ends of the stroke to form a thin film.

6. Spray Gun Painting

A mechanical means of applying paint is used by manufacturers who make farm machinery, trucks, automobiles and tractors, and many other types of equipment found around the home and farm. Spray painting is similar to brush painting in that it improves the appearance and life of an item, thus making it more valuable.

There is little comparison in the cost of spray painting and brush painting equipment. If there is much painting to be done, the labor required to brush paint will offset the cost of good spray painting equipment.

Spray painting is the best way to paint farm machinery.

An area or piece of machinery can be painted more rapidly with a spray gun than with a brush. It is estimated that a spray gun will cover five to twenty-five times the area that can be covered with a brush in the same period of time. This is one reason why farm machinery repair shops and manufacturers use the spray gun instead of the paint brush.

a. Preparing the Paint for Spraying

Mixing, thinning, and straining are very important steps to observe when using a spray gun. The steps are:

(1) When mixing paint for brush or spray painting pour off the oil or thin material into another can, stir the pigment, and remix it with the thin material. The cup or tank is not used as a mixing container.

(2) The adding of a thinner to paint will prevent it from running, but it also reduces the thickness of the paint film.

(3) Paints should be strained through a fine wire screen or an old nylon stocking before spraying. Even though a wire screen is used over the bottom of the fluid tube, it is still necessary to strain the paint.

Transparencies Nos. 2, 3, and 4

b. How to Position a Spray Gun

(1) Distance of Gun from Surface - The gun should be held 6 to 8 inches from the surface. A good practice is to place the thumb on the nozzle (air cap) point and stretch the fingers forward to the surface. Incorrect distance causes the following problems:

(a) If the gun is held too close, the paint is put on thickly. If the surface is vertical, the paint will sag.
(b) If the gun is held too far away from the surface, a sandy finish and excessive dusting will result, causing an inferior finish.

(2) Gun Position - The correct position to hold a spray gun is vertically to the surface. It should also be moved in a parallel line to the surface. The overlap should be about 50% of each previous lap on the surface. Several problems may develop if the gun is held improperly. The problems may include:

(a) Uneven covering will develop if the gun is arced at each end of the stroke. Excessive overspray develops where the gun passes near the surface.
(b) If the gun is pointed upward while painting, the pattern will be heavy at the bottom. If it is pointed downward, the pattern or coat will be heavy at the top.
(c) The trigger should be pulled just after the stroke begins and released just before the stroke ends, otherwise the pattern may be heavy at the beginning and end of each stroke. A light pull on the trigger may cause feathering and a small pattern. This practice is desirable when a stroke is butted next to another.

(3) Painting Edges and Corners - Edges and corners should be sprayed before spraying the flat surfaces. Inside corners should be sprayed by making strokes over each face of the corner surface separately. Both sides of an outside corner are painted with one stroke.

(4) Slender Surfaces - The circle of a spray pattern should be just large enough to cover the surface. Excessive over-spray will result if the pattern is too large.

(5) Round Surfaces - Round work is sprayed by following the curve with the pattern.

c. Cleaning the Spray Gun

It is necessary to use a good solvent, such as paint thinner, painter's naphtha, or benzene to thoroughly clean the painting equipment. Spray gun cleaning steps include:

(1) Clean the cup or tank with a solvent.

(2) Add solvent to the clean container and blow it through the gun with compressed air.

(3) Take the nozzle apart and clean the parts in the solvent.

(4) If a tank is used, run enough solvent through the hose to completely clean it of all paint.

(5) Wipe the equipment clean and remove excess solvent.

(6) Place the nozzle part of the gun (still attached to the gun) in a solvent if it is to be idle for an hour or two. Some paints will dry on the nozzle within an hour or two.

d. Spray Painting Tools

Spray painting tools include the following:

Suction or Pressure Type Gun - The pressure type is recognized as the most popular spray gun.

Air Compressor

Paint Pressure Tank

Hose to convey air and hose to convey materials (paints)

Air controlling device (gauge and regulator on tank)

7. Important Things to Observe in Painting

a. Paint during dry seasons when the temperature is about 65 degrees. Never paint (brush or spray) in the hot sun.

b. There are several grades of paint. Due to its lasting effect and cost of applying, the best grade is usually the cheapest due to its lasting quality.

c. While painting rough surfaces it may be necessary to move the gun or brush more slowly than when painting smooth primed surfaces.

d. If the paint brush is used for more than a day, it may be immersed in linseed oil or paint thinner. At the end of a painting job the brush should be washed several times in kerosene or paint thinner, then washed in soap and water. A brush used in water-thinned paints should be washed daily with soap and water. The shape of brush bristles can be maintained by wrapping them in paper after they have been wahsed or properly hanging the brush by the handle.

e. Spray gun equipment should be washed daily with no exceptions.

8. Safety Precautions to Observe

a. Flammable liquids such as thinners, turpentine, and lacquers should be handled in safety containers and never used around a flame or fire. A safeguard against a fire is to have a fire extinguisher (pressurized dry chemical type) available.

b. When the ventilation is poor or when working in close quarters with the spray gun, it is a good practice to use a respirator, and maybe wear gloves or grease the hands and face to protect against fumes or vapors.

c. Painting should be done in areas free from running motors and engines, free of devices that will cause electric sparks, and free of open flames (heaters).

d. It is very important that a spray unit have an automatic switch to keep the pressure at a constant level and a safety valve. Usually not more than 50 pounds of pressure is used on the paint cup.

e. When painting large equipment such as combines and harvesters, ladders should be checked for sound footing, and if possible the ladder should be tied to the machinery being painted. A rope or string can be used to hoist a spray gun from the floor or ground to the position for spraying. This frees both hands for climbing a ladder.

f. Due to toxic materials found in many paints, the containers should be kept closed, and discarded paint should be covered in a deep hole. Animals may lick or eat exposed toxic paint materials.

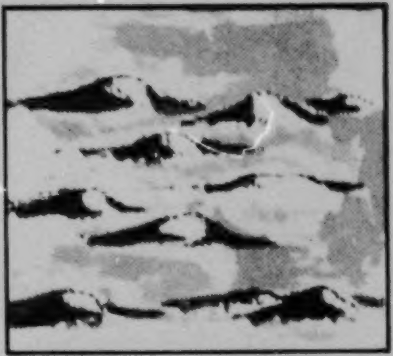
References:

1. Phipps, Lloyd J., Mechanics in Agriculture, The Interstate Printers and Publishers, Inc., Danville, Illinois, 1967

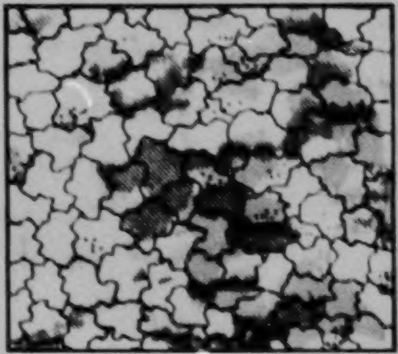
2. "Selection and Use of Spray Painting Equipment", Iowa State University, Ames, Iowa, 1960

3. "Spray Painting", University of Illinois, Urbana, Illinois, 1970

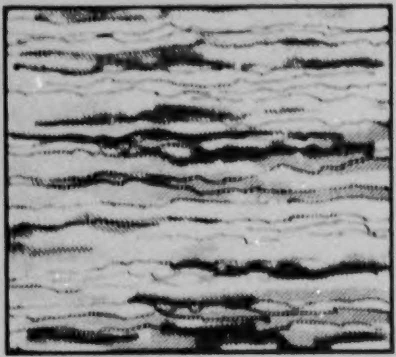
PAINT FAILURES



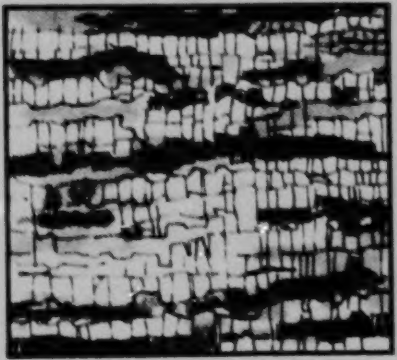
BLISTERING



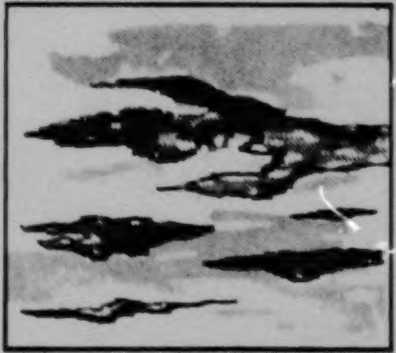
CRACKING & ALLIGATORING



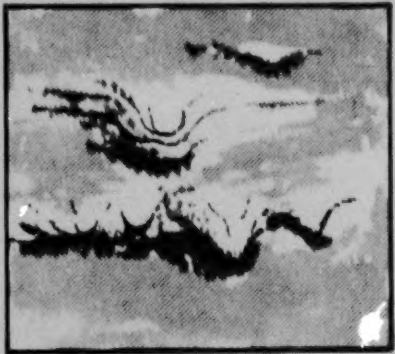
WRINKLING



CRACKING & SCALING

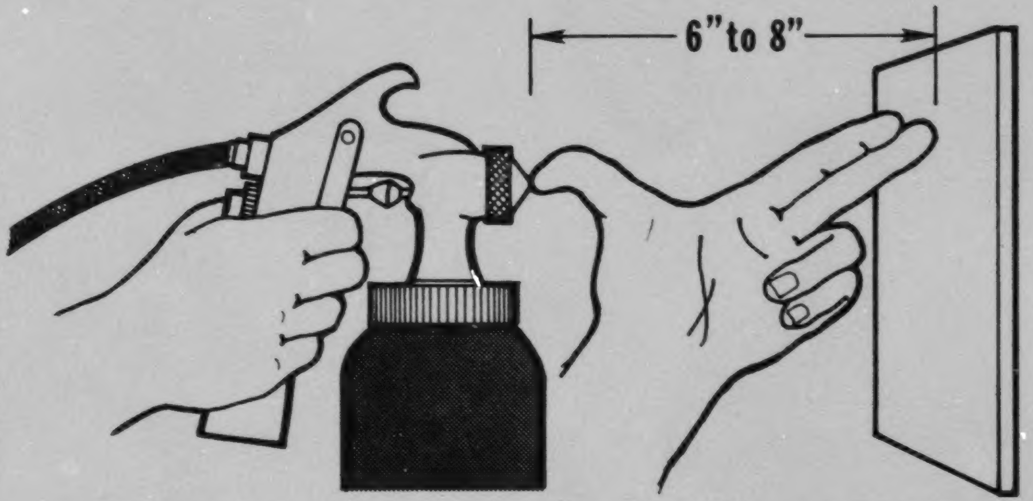


PEELING

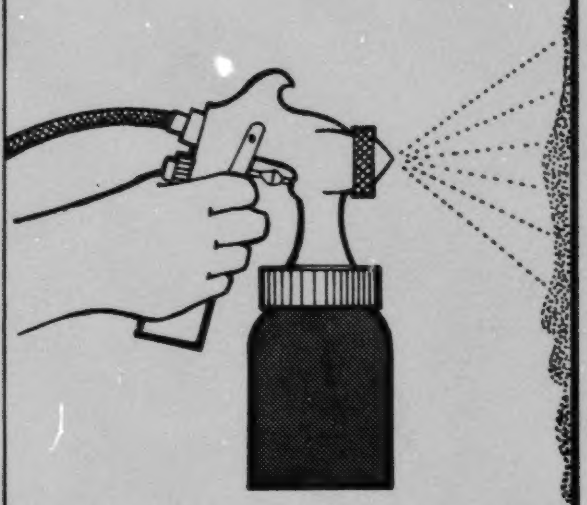


RUNNING & SAGGING

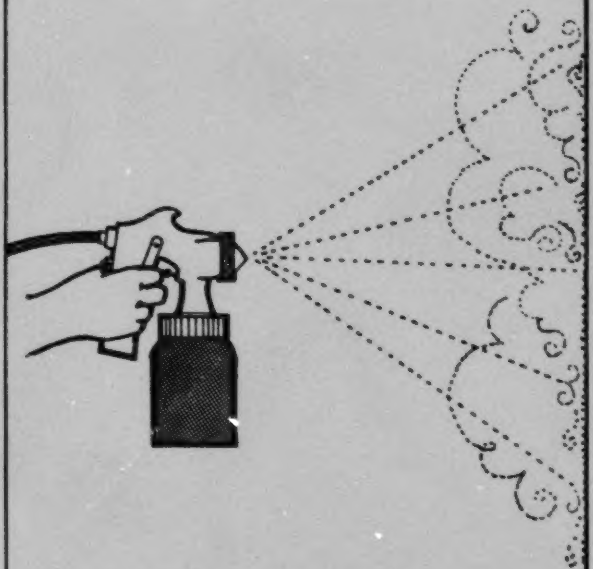
SPRAY GUN POSITION



CORRECT DISTANCE FROM SURFACE

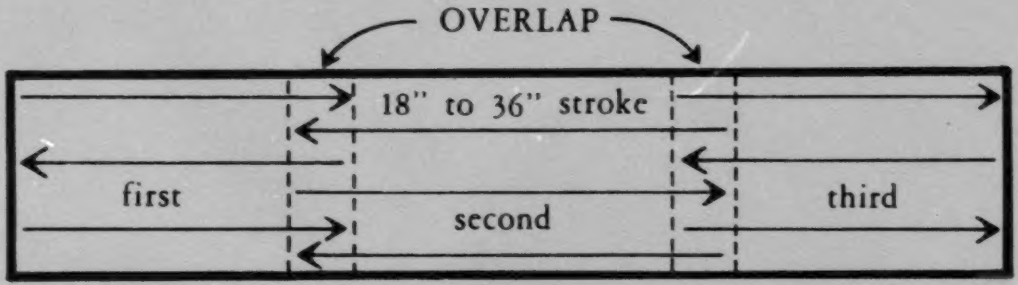


TOO CLOSE



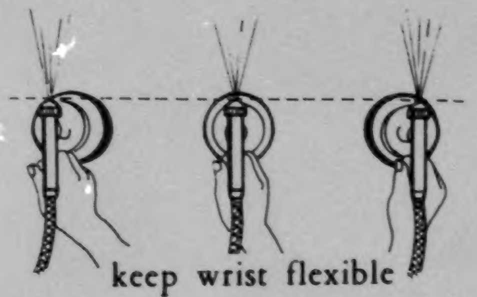
TOO FAR

USE OF SPRAY GUN

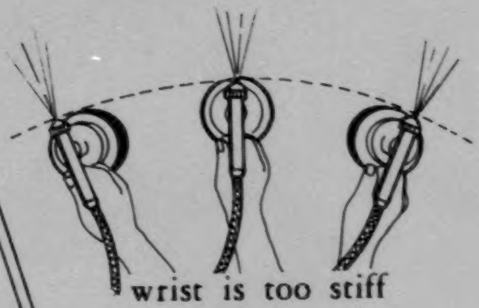

OVERLAP
18" to 36" stroke
first
second
third

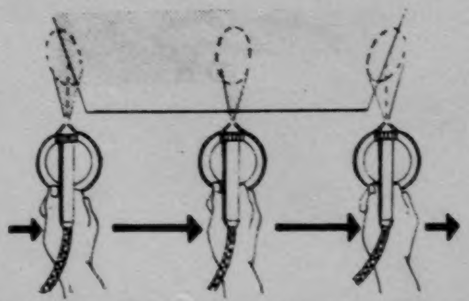
OVERLAP END OF PARALLEL STROKE

MOVE GUN IN STRAIGHT LINE


keep wrist flexible

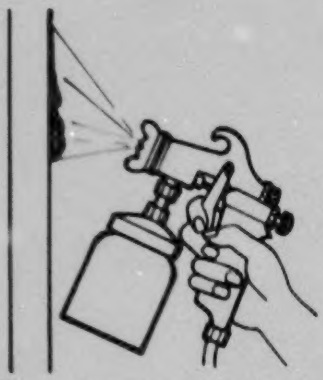
ARCING GIVES UNEVEN COATING


wrist is too stiff

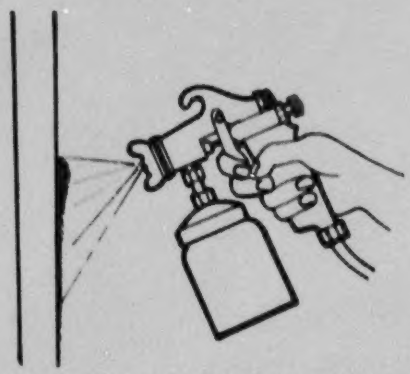


- PULL TRIGGER
- HOLD TRIGGER TIGHT
- RELEASE TRIGGER

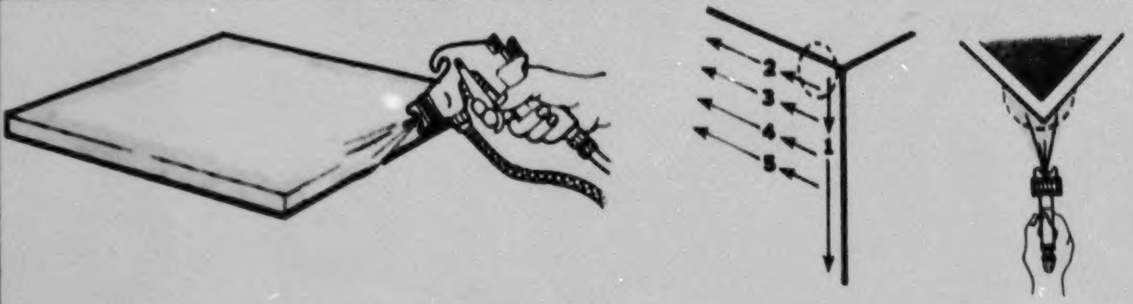
USE OF SPRAY GUN



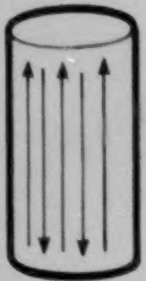
NOZZLE POINTED UPWARD



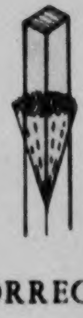
NOZZLE POINTED DOWNWARD



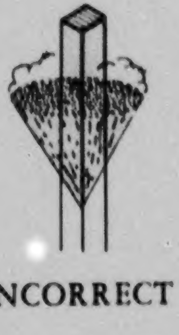
SPRAYING EDGES & CORNERS



small round work
sprayed parallel



CORRECT



INCORRECT

GENERAL AGRICULTURAL MECHANICS

Unit J: Servicing and Repairing Small Gasoline Engines

Topic 1: Two and Four Stroke Engine Operation

Suggested Procedures and Activities: The use of partially disassembled engines as teaching aids during the class discussion may be helpful in presenting the lesson.

Transparency No. 1

1. The Use of Two and Four Cycle Gasoline Engines

The small internal combustion engine is a very important source of power both on and off the farm. It is estimated that more than 6,000,000 small engines are produced annually in the United States. The total number of single-cylinder engines in the United States may exceed 70,000,000.

a. Small engines are adaptable to many kinds of jobs because they are:

Lightweight
Portable
Compact
Economical on fuel use
Air-cooled
Furnish power
Easy to service and repair

b. Some equipment that may be powered by small engines is as follows:

Mowers
Chain saws
Conveyors
Elevators
Post hole diggers
Air compressors
Outboard motors
Small seed grinders
Brush cutters
Rotary tillers
Irrigation pumps
Sprayers
Concrete vibrators
Concrete surfaces
Small tractors
Generators

c. Small engines used to power this type of equipment are known as internal combustion reciprocating engines. A combustible mixture of petroleum products and air in the piston chamber (cylinder) is burned to form heat which is the source of power. The shaft is turned as pressure is applied to the top of the piston, forcing it down as the air-fuel mixture burns and expands in the cylinder. The piston is connected to a connecting rod which is connected to the crankshaft.

2. Major Differences in Two and Four Cycle Engines

Two Cycle	Four Cycle
Piston or thin piece of metal over an opening (reed valve) serves as a valve.	Has regular intake and exhaust valves.
Oil is mixed with gasoline and used as a fuel and lubricant.	Oil is used entirely as a lubricant.
One revolution of the crankshaft is a cycle.	Two revolutions of the crankshaft are one cycle.
Crankcase contains a fuel that also serves as a lubricant.	Crankcase contains only a lubricant.
Two strokes of the piston complete one cycle.	Four strokes of the piston complete one cycle.
Has no camshaft, valve lifters, or valve springs.	Has valve lifters, valve springs, and a camshaft.
Less difficult to handle on small hand equipment.	More difficult to handle on very small equipment.
More difficult to start than four-cycle.	May start more easily than two-cycle. Burned and unburned gases are not likely to mix.
More power produced per unit of weight. This is important in using light equipment.	Less power produced per unit of weight because there is a power stroke every two revolutions of the crankshaft.
May be used in any position due to having no crankcase and float type carburetor.	Used in certain position due to having oil in crankcase and float type carburetor.
Lubricating oil is mixed with engine fuel, resulting in a less efficient job of engine lubrication.	Easy to lubricate. Fuel is separated from the lubricating oil.
Cost is usually less due to simpler construction.	Costs more than two-cycle engine.

3. Method Used to Distinguish Between a Two and Four Cycle Engine

Check the operator's manual for crankcase capacity or the kind of oil to use. If the crankcase capacity is discussed, the engine is a four-cycle. The mixing of oil and gas would identify the engine as a two-cycle.

Check to see if the engine has an oil sump (place to add oil or a place to drain the oil). A four-cycle engine has a sump; a two-cycle does not.

Check to determine whether or not the engine has an exhaust muffler at the end of the cylinder, and if it does, it is a four cycle engine. The muffler is located in the center of the cylinder on a two cycle engine.

Check the compression by disconnecting the spark plug wire, mark the flange of the starter pulley and crank the engine by hand. On a four-cycle engine, resistance is felt on every other revolution. Resistance is caused by compression on each revolution of a two-cycle engine.

Transparencies Nos. 2 and 3

4. Types of Small Engines

a. Two Stroke Cycle Engines - The piston makes two strokes and the crankshaft turns one complete revolution in completing a cycle from power stroke to power stroke. Actually there are five events that take place. They include: intake, compression, ignition, expansion (power), and exhaust. All these events take place in two strokes of the piston.

As the piston moves upward, a partial vacuum is created in the crankcase. This causes the reed valve (valve between crankcase and carburetor) to open. An air fuel mixture flows into the crankcase from the carburetor. As the piston moves down the air fuel mixture is compressed in the crankcase. The reed valve is closed. Compressed air-fuel enters the cylinder through a by-pass port uncovered by the piston. This intake port is covered again as the piston moves upward to compress the air-fuel mixture in the cylinder and at the same time a new fuel charge is drawn into the crankcase.

Near the top of the compression stroke the fuel mixture is ignited forcing the piston down and creating a power stroke. The sudden expansion of the burning mixture causes this action. On this downward stroke most of the burned air-fuel mixture is exhausted as the piston nears the bottom of the cylinder.

b. Four Stroke Cycle Engines - There are two complete revolutions of the crankshaft for each power stroke of the piston or a complete cycle of the engine. A complete cycle consists of the following four strokes in the cylinder:

(1) Intake - As the piston moves downward, a partial vacuum is created in the cylinder. A mixture of vaporized fuel and air is forced into the cylinder from outside air pressure through the intake valve. The exhaust valve is closed.

(2) Compression - Both intake and exhaust valves are closed during this stroke. The upward movement of the piston compresses the air-fuel mixture between the piston top and cylinder head.

(3) Power - Both valves remain closed on this stroke. The fuel-air mixture is ignited by an electrical spark which causes an explosion in the cylinder and forcing the piston down. This downward movement delivers power to the crankshaft.

(4) Exhaust - As the piston moves upward, burned gases are forced out of the cylinder through the open exhaust valve. This valve closes at the end of the stroke and the intake valve opens as the next cycle begins.

Transparency No. 4

5. General Compression Information

In order for the fuel-air mixture to be compressed by the piston in the top of the cylinder, no leakage must appear between the piston and cylinder wall. Compression rings are fitted in a groove near the top of the piston so that they may serve the following functions:

Exert pressure on the cylinder wall to compress the fuel-air mixture in a small space.

Scrape the oil back into the crankcase and away from the combustion chamber to keep it from being burned.

Each cylinder has a perforated oil ring located below the compression ring or rings. The perforations permit the oil to be spread evenly on the cylinder wall. The amount of fuel-air mixture to be compressed in a cylinder depends on the piston displacement (space displaced by the piston in its up and down travel). The area of displacement depends on the size of bore and the length of stroke. The following formula is used to compute piston displacement in cubic inches:

Piston displacement = $\frac{(\text{bore})^2}{4}$ X   X stroke

Example of a 2 inch bore and a 1 3/4 inch stroke:

$\frac{2 \text{ X } 2}{4}$ X 3.1416 X 1 3/4 = 5.5 cubic inches piston displacement

Most small engines vary from 5:1 to 6:1 compression ratio. The ratio is a good comparison of the cylinder area, when the piston is at the bottom and at the top of the stroke. Generally, an engine with a high compression ratio has more power than one with low compression.

References:

1. Stephenson, George E., Small Gasoline Engines, Delmar Publishers, Albany, New York, 1973
2. "Small Engines, Volume I", American Association for Vocational Instructional Materials, Athens, Georgia, 1975
3. "General Theories of Operation", Briggs and Stratton Corporation, Milwaukee, Wisconsin, 1971
4. "Small Engines - Principles of Operation, Trouble Shooting, and Tune-Up", University of Illinois, Urbana, Illinois, 1970
5. "The Two Cycle Engine", University of Illinois, Urbana, Illinois, 1970

WHY SMALL ENGINES ARE ADAPTABLE TO MANY KINDS OF JOBS

LIGHTWEIGHT

ECONOMICAL ON FUEL USE

COMPACT

SOURCE OF POWER FOR SMALL EQUIPMENT

PORTABLE

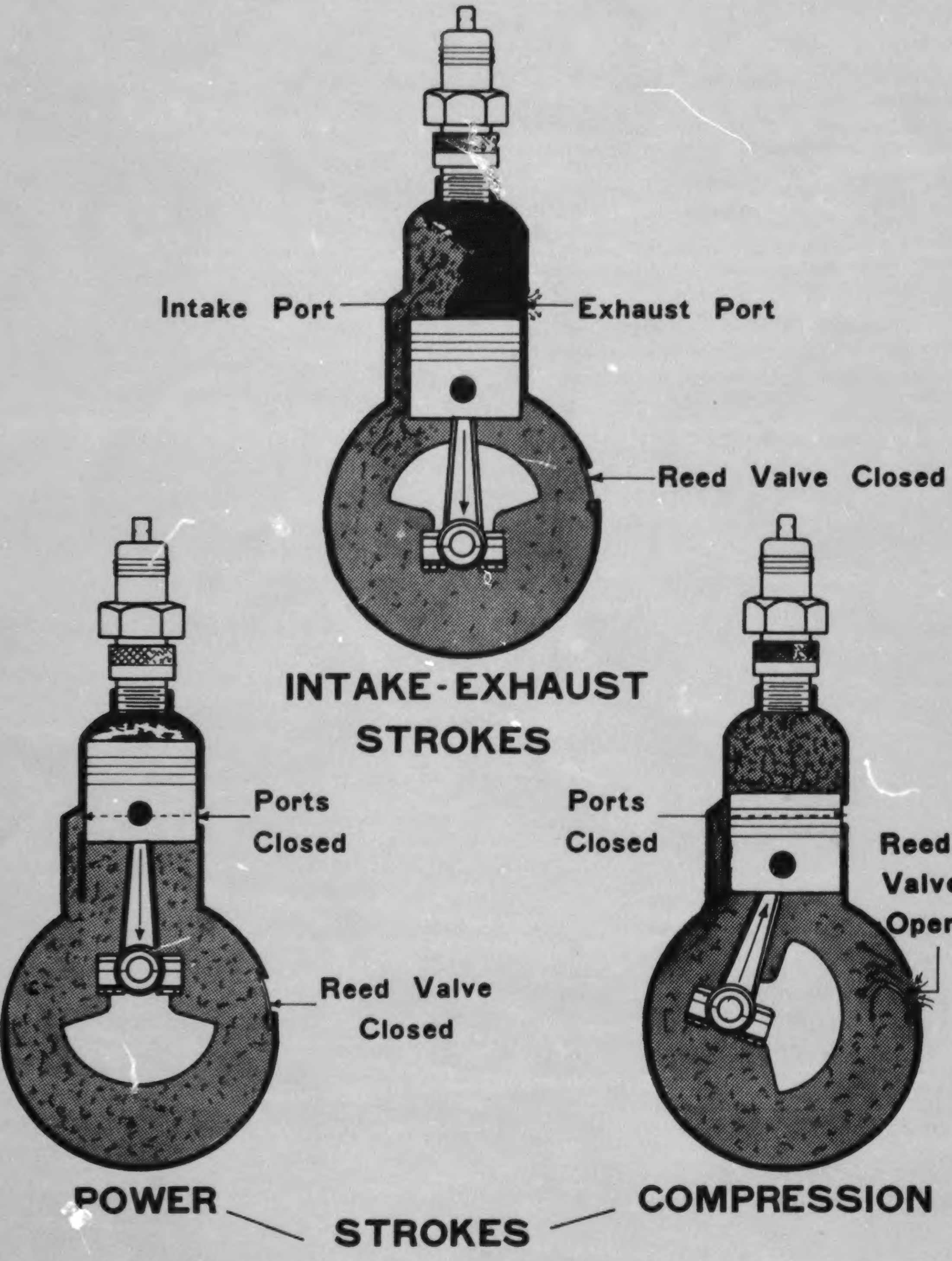
AIR-COOLED

EASY TO SERVICE

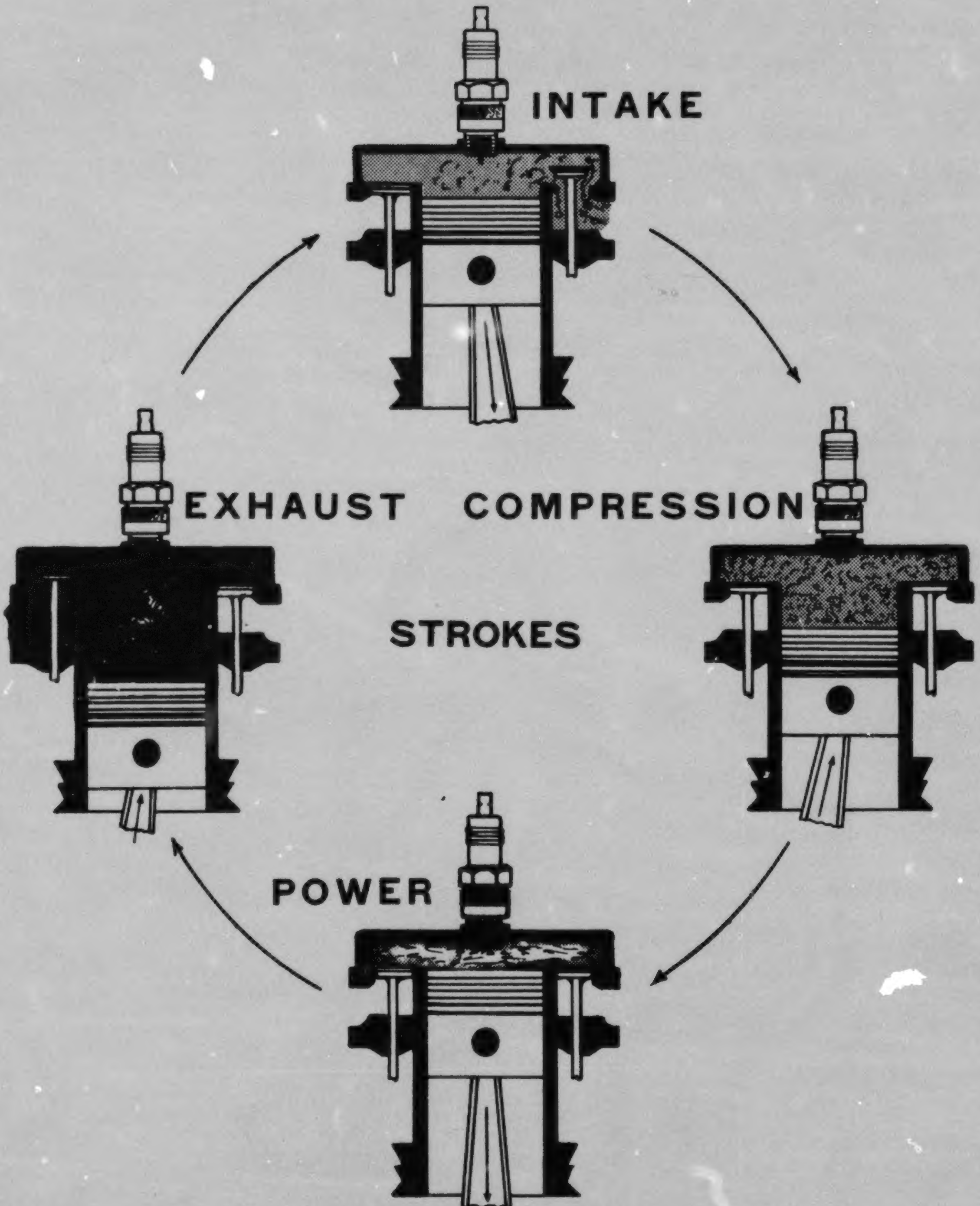
EQUIPMENT POWERED BY SMALL ENGINES

MOWERS
CHAIN SAWS
CONVEYORS
ELEVATORS
POST HOLE DIGGERS
SMALL FEED GRINDERS
CONCRETE SURFACERS
AIR COMPRESSORS
BRUSH CUTTERS
ROTARY TILLERS
IRRIGATION PUMPS
SPRAYERS
CONCRETE VIBRATORS
GENERATORS
OUTBOARD BOATS
SMALL TRACTORS

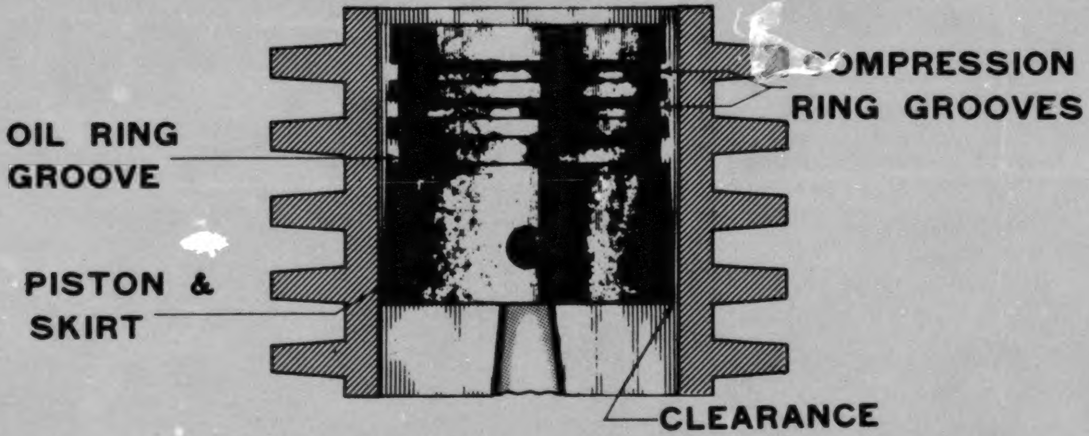
OPERATION OF A TWO-CYCLE ENGINE


Intake Port
Exhaust Port
Reed Valve Closed
INTAKE-EXHAUST STROKES
Ports Closed
Reed Valve Closed
Ports Closed
Reed Valve Open
POWER
COMPRESSION
STROKES

OPERATION OF A FOUR-CYCLE ENGINE


INTAKE
EXHAUST
COMPRESSION
STROKES
POWER

PISTON CLEARANCE. DISPLACEMENT, AND RATIO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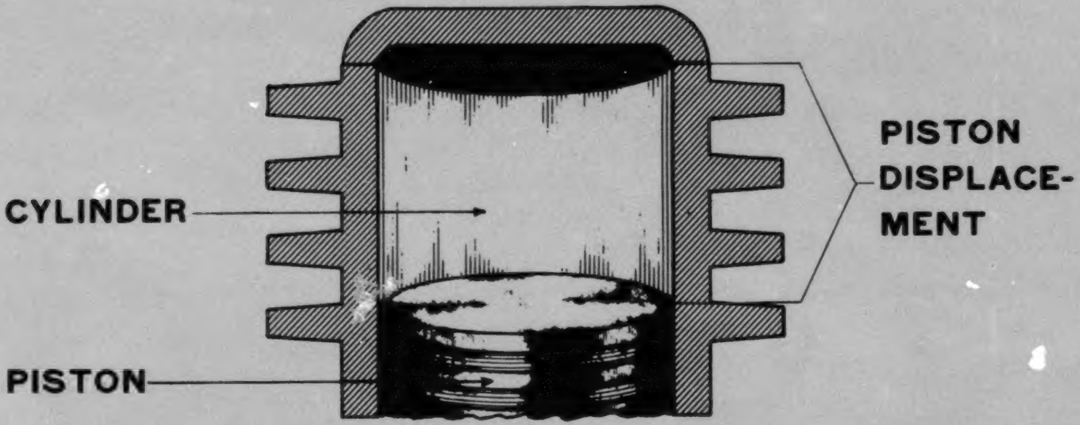
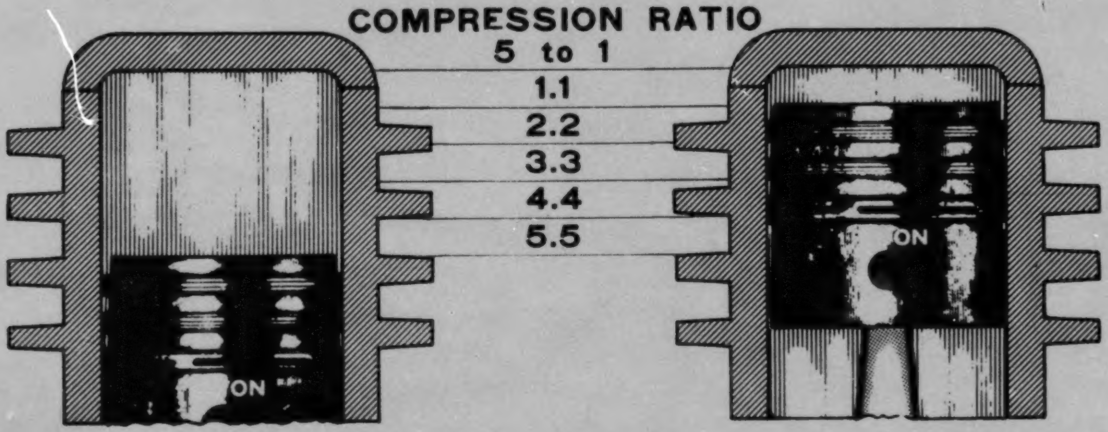
RING GROOVES
OIL RING
GROOVE
PISTON &
SKIRT
CLEARANCE


PISTON
DISPLACE-
MENT
CYLINDER
PISTON


COMPRESSION RATIO
5 to 1
1.1
2.2
3.3
4.4
5.5
ON
ON

GENERAL AGRICULTURAL MECHANICS

Unit J: Servicing and Repairing Small Gasoline Engines

Topic 2: Disassembly and Assembly of the Small Engine

Suggested Procedures and Activities: The use or presenting the parts of a partially disassembled engine can be very helpful when explaining the information found in this topic.

1. Introduction

Preventive maintenance for small engines is similar to that for larger engines. Maintenance practices such as periodic oil level checks, spark plug inspection, keeping the engine clean and changing oil as recommended by the service manual are necessary for long engine life. Normal wear will eventually cause many moving parts to be replaced or normal wear will cause a complete overhaul. Small engines may be reconditioned at a reasonable cost if proper tools are available. In some cases it may be more economical to buy a new engine than to pay for a complete overhaul.

If a small engine is to have a useful and prolonged life, it is very important that the recommendation be followed in the operator's manual.

Transparency No. 1

2. How to Clean an Engine

The engine should be thoroughly cleaned before it is disassembled. The steps in cleaning are:

a. Dry dirt should be loosened with a stiff brush and putty knife.

b. Blow loose dirt and other foreign material off the engine with an air hose, but avoid getting dirt into internal parts of the engine.

c. Use solvent and rags to remove oil and grease. It is unsafe to use gasoline as a solvent. Remove air deflectors, cylinder baffles, and blower shroud in order to make the cleaning easier.

Transparencies Nos. 1 and 2

3. Disassembling a Small Engine

Due to the many different makes (brand names), models, and types of small engines, the general steps used to disassemble small engines may vary. However, there are general steps that may be used to disassemble most engines. A general procedure is as follows:

a. Preparing the engine for disassembly involves several important steps.

(1) Remove gasoline or fuel mixture from the fuel tank, fuel lines, and carburetor. If fuel is to be reused it must be stored in a clean and dry container.

(2) Drain the crankcase by removing the drain plug. Oil will flow more freely if it is warm; therefore, if the engine will start it should be started and operated long enough to heat the oil. The oil pump can be cleaned after it is removed from the engine. Dispose of used oil.

(3) Remove the air cleaner assembly (stud, wing nut, and clamp). Drain oil from the oil bath type cleaner and discard. Any type of air cleaner (oil bath or dry) should be set aside for servicing.

b. After the engine has been cleaned and fuel and oil removed it should be ready to disassemble. But, first prepare an information sheet to record important data about damaged or broken parts as the engine is being disassembled. The disassembly procedure may be as follows:

(1) Remove the spark plug by using a spark plug socket wrench. This type of wrench is cushioned to protect the porcelain part of the plug. The gap and condition of electrode may be checked and recorded. A compression reading and spark output test may be taken at this point.

(2) Disconnect the governor link. The governor spring should be removed without excessive stretching so the link will not be distorted. In order to reconnect the governor, throttle, throttle linkage, and other fuel connections, check the operator's manual to determine whether or not assembly information is available. If this information is not available, make sketches before removing the linkage.

(3) Disconnect the fuel supply lines and carburetor. If the engine has a gravity flow type system, remove the fuel tank and then disconnect the carburetor from the tank and engine. If the engine has a suction

system, remove the tank and carburetor together.

(4) Use penetrating oil on muffler threads and remove the muffler if it is to be replaced; otherwise, leave it attached to the engine.

(5) After the engine has been removed from its mounting (equipment), remove the starter. The method used to remove the starter will depend on the type of starter connected to the engine. Some starters are fastened to the flywheel housing by three or four bolts. A certain type of starter may be located in the flywheel housing. It may be necessary to remove the cowling on some makes of engines before removing the starter.

If the manual recoil starter is to be disassembled, it should be placed in a vise or secured by C-clamps before working on it. The rope can be removed by pulling it all the way out and locking the starter in place with vise-grip pliers. If the spring is removed, the starter may be rewound by a screwdriver or special rewinding tool. The two most popular types of manual starters are the rope-wind and the windup. Both types have a recoil spring. Some small engines are equipped with regular starter motors that operate off batteries, the same as automobiles. Less common are 120-volt alternating-current starting motors for small engines.

Transparencies Nos. 3, 4, and 5

c. Disassembly of the main body of the engine and its parts:

(1) Remove the valve chamber cover, cylinder head, and gasket. It may facilitate reassembly if the bolts are marked as they are taken from the cylinder head. Some head bolts are longer than others and serve purposes other than holding the head in place. The bore and stroke can be measured at this stage of disassembly.

(2) Check the flywheel shaft to determine whether the shaft is threaded right or left handed. This is accomplished before removing the nut. Remove the protective screen if one is mounted on the flywheel assembly.

The flywheel may be removed by using a special holder or wood blocks and a heavy duty socket wrench. If screwdrivers or wrecking bars are used as a holder, it is possible the fins will be damaged, throwing the flywheel out of balance. The socket wrench handle should be tapped lightly with a soft mallet to loosen the nut.

If the shaft is tapered and the flywheel is secured by a key, it may be removed by holding the engine in place about two inches from the work table and tapping the shaft with a lead hammer or striking a hardwood block placed on the shaft. An impact nut on the end of the shaft will protect the threads. A special wheel puller may also be used to remove a flywheel mounted on a standard shaft. It may be appropriate to remove the ignition at this point during the disassembling operation. Most magneto systems are located back of the flywheel shroud. On some engines the magnets are cast into the flywheel and cannot be removed. Some of the larger engines are equipped with starter-generators or alternators which must be removed.

(3) Open the crankcase on four-cycle engines by removing the oil sump or PTD plate. Remove the rod-bearing access plate or the carburetor or reed plate on two-cycle engines. Engines with ball bearings supporting the crankshaft have grease seals and locking nuts that must be removed before the engine side can be removed. Engines with sleeves around the crankshaft may not be sealed in the same manner as ball bearings. Pry out the seal with a sharp tool and remove locking nuts and bearings. Before removing the side or oil sump of an engine to expose the crankshaft, rough places may be corrected on the exposed ends.

Open the crankcase without disassembling the cam gear. Most timing gears have timing marks. If the marks are not visible, make them visible by using a center punch before unmeshing the gears. Some engines have alignment dowels that must be removed before opening the engine.

(4) Remove the cap screws from the bearing cap. Push the piston and rod out through the top of the engine if the engine head is removable. If the cylinder head is not removable, the piston assembly must be removed from the bottom, which means that the crankshaft must be removed. Before removing the piston, it may be advisable to move the piston to the bottom dead center position and examine the upper end of the cylinder for a sharp ridge. If a ridge is present, remove it with a ridge reamer before pushing the piston through the top.

(5) If a cylinder does not require reboring, disassemble the piston and rod assembly in the following order:

(a) Remove the piston retainer rings that are located on each end of the piston pin.

(b) Use a piston ring expander to remove the rings. Rings can be removed by using a small screwdriver or long-nose pliers.

(c) As the rings are removed, place them in order and the proper side up so they may be replaced in the proper grooves.

(6) Valves are easier to remove if a valve-spring compressor is used to press the springs before trying to remove the valve retainer. The valve should be held closed with the hand if it is removed by using a screwdriver. Remove the retainer lock with pliers or a screwdriver or pliers depending upon the type of retainer lock.

Remove the valves and mark them exhaust or intake. If the springs and caps are removed they should be marked so they may be placed in the proper valve hole.

If burrs are found on the valve stem, they should be removed with a file before forcing the valve through the opening.

Two-cycle engines have a reed valve or the piston serves as a sliding valve. The reed valve is usually not removed unless it is necessary to replace it.

(7) Remove the camshaft by removing the gear cover or base plate, that is, if the engine has a vertical crankshaft or does not have an oil sump. Mark the crankshaft and the cam gear.

The crankshaft should be turned so that the timing marks are aligned on the compression stroke. Both valves should be closed. Pressure from the tappets is relieved by this action. The tappets will remain in place while removing the camshaft if the crankcase is turned on its side or placed upside down. Mark the valve tappets and remove them one at a time. The tappets should be reinserted in the same holes from which they came.

(8) Remove the retaining rings on each end of the crankshaft if rings are part of the unit, and remove the tapered-roller bearing shaft by hand. The nontapered bearing type must be tapped or pressed out. Naturally, the seals should be removed during this operation. On some engines the crankshaft is removed from the housing before removing the bearing plate.

Transparency No. 6

4. Reassembling Engine Parts

a. Replace the bearing on the crankshaft by heating it in oil and shipping the bearing on the crankshaft while it is still hot. As the metal cools, the bearing will tighten on the shaft.

b. In many four-cycle engines that are made of aluminum alloy, the tappets are oiled and installed in the order they were removed. After the tappets are replaced, the crankshaft and the cam gear are installed. The timing marks on the crankshaft and cam gears must be aligned. In cast iron engines the tappets are attached to the cylinder and then the cam gear is installed.

c. Clean the cylinder walls with an oil soaked rag. Check the ring gap and install rings in the correct position on the piston. Use a ring compressor to install the rings.

Install the oil ring and then the compression rings. The center ring may have a scraper groove; therefore, it must be installed with the scraper groove down. If the top rings have a recess, the recess goes up. Attach the connecting rod to the piston. The piston and rod may be marked to identify rod and piston alignment. Some two-cycle engines have pistons with a small pin or knob to prevent the ring from turning. They must be installed properly.

Check the ring gap and groove with a feeler gauge. Insert the piston in the cylinder so that the connecting rod is in contact with the block. Use a ring compressor to squeeze the rings into the grooves. Push the piston into the cylinder.

Oil all parts and put on the bearing cap. Tighten the bearing bolts with a torque wrench, using about 90 inch-pounds. If the engine turns freely, the bolts should be locked. If an engine does not turn freely, the piston should be checked to determine whether or not they were installed backwards.

d. After the valves have been refaced and seated properly they should be replaced in the engine. Use a feeler gauge to check valve-tappet clearance. The valve springs and keepers should be replaced by using the spring compressor and pin inserter. Needle nose pliers can be used to insert the pin. Turn the engine several times to be sure the valves are opening and closing properly.

e. The engine head should be replaced after the valves are installed and seated. Use a new head gasket between the head and cylinder. The head bolts should be drawn up evenly with a socket wrench and the final tightening should be done with a torque wrench. The bolts should be tightened evenly, alternating the tightened bolts from one side to the other.

5. Replacing Other Major Parts of the Engine

Other major parts may be assembled in the following order:

Spark plugs
Starter pulley or clutch
Governor blade
Breather assembly
Muffler and fuel tank
Carburetor and linkage (align pneumatic governor)
Blower housing
Fuel line

6. Operation Steps

   a. Refill crankcase (4-cycle engine) with the proper oil.

   b. Refill the oil bath air cleaner (if this part is on the engine) with clean oil.

   c. Use a proper fuel mixture (2-cycle engine) to fill the fuel tank.

   d. Adjust main jet valve on carburetor so engine will run smoothly.

   e. Hold the throttle shut and adjust idle speed so engine operates smoothly.

   f. Set the idle speed by adjusting the idle screw.

   g. After the engine has operated a few minutes, adjust the carburetor so that the engine will accelerate at different speeds.

The head bolts should be retightened with a torque wrench after about 10 hours of operation. It may be necessary to readjust the carburetor after the engine has been in operation about 10 hours.

References:

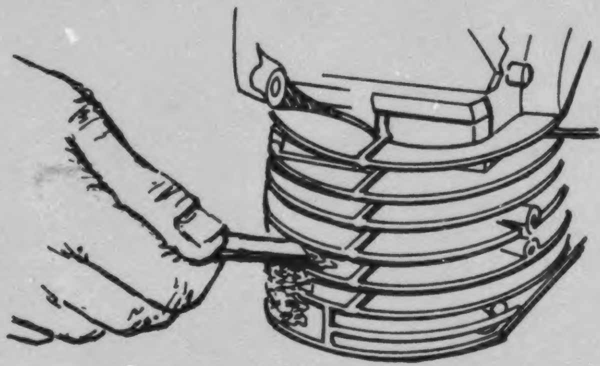
1. "Small Engines - Maintenance and Repair, Volume II", American Association for Vocational Instructional Materials, Athens, Georgia, 1974

2. "Repair Instructions IV", Briggs and Stratton Corporation, Milwaukee, Wisconsin, 1973

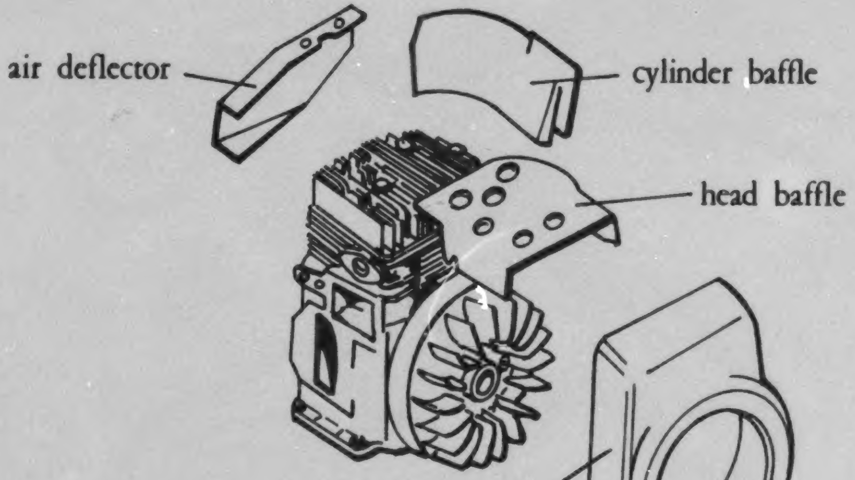
3. "Small Engines Service Manual", Intertec Publishing Corporation, Kansas City, Missouri, 1976

4. "Small Engines - Repair and Overhaul", University of Illinois, Urbana, Illinois, 1970

DISASSEMBLING ENGINE

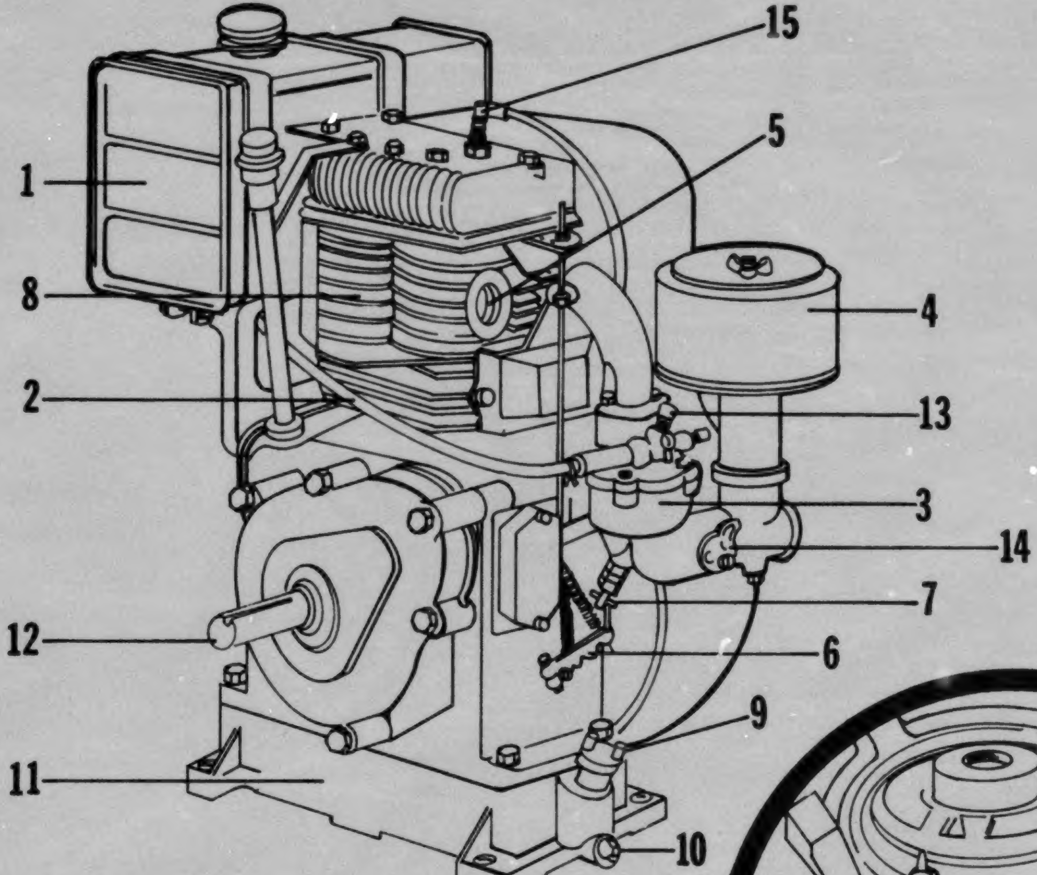


USING SOFT SCRAPER ON CYLINDER HEAD FINS


air deflector
cylinder baffle
head baffle
blower shroud

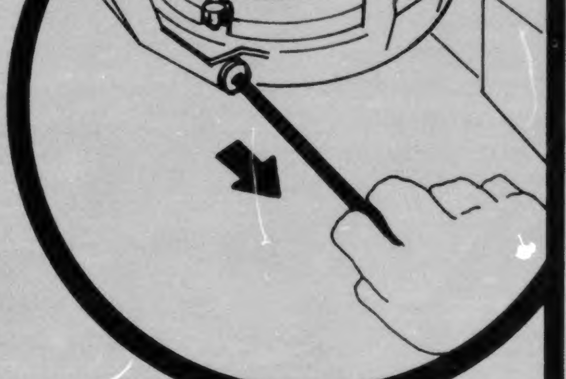
ENGINE COWLING

SMALL ENGINES



MAJOR ENGINE PARTS

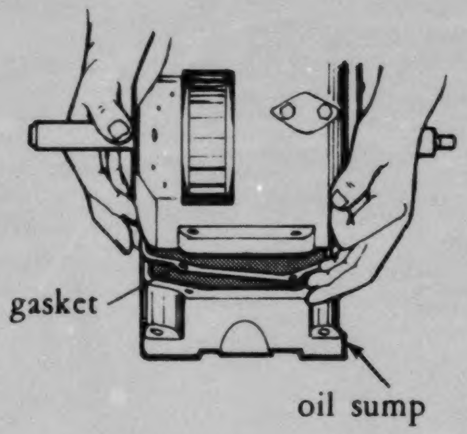
1. Fuel Tank
2. Fuel Line
3. Carburetor
4. Air Cleaner
5. Muffler
6. Speed Control Lever
7. High Speed Adjustment
8. Cylinder Head
9. Oil Filter Plug
10. Oil Drain Plug
11. Oil Sump
12. Power Shaft
13. Idle Screw
14. Choke Lever
15. Spark Plug

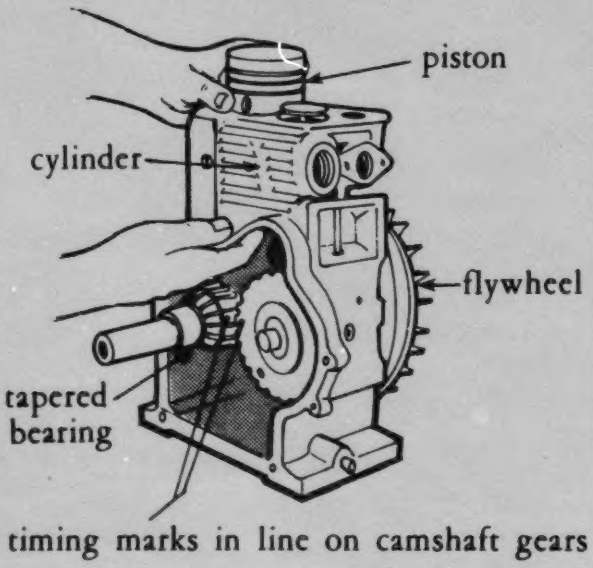


RECOIL STARTER

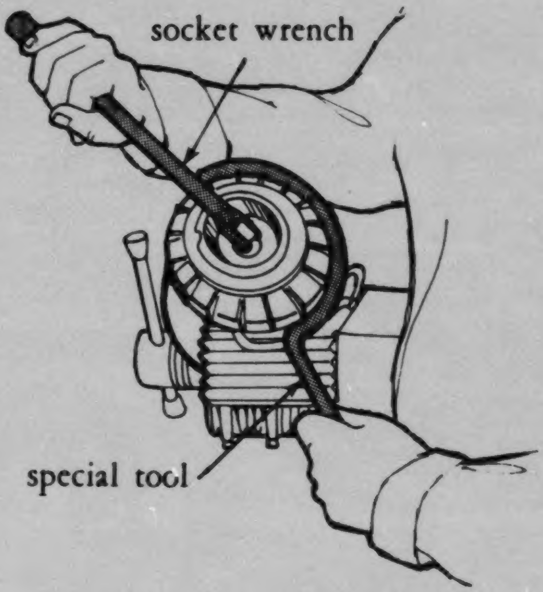
DISASSEMBLING ENGINE

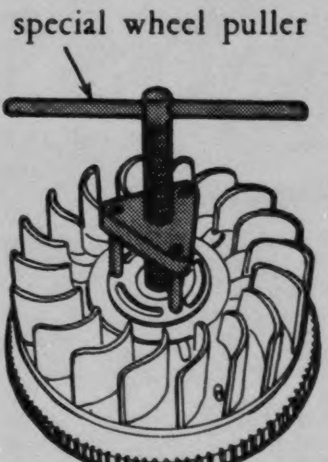
OPENING ENGINE


gasket
oil sump

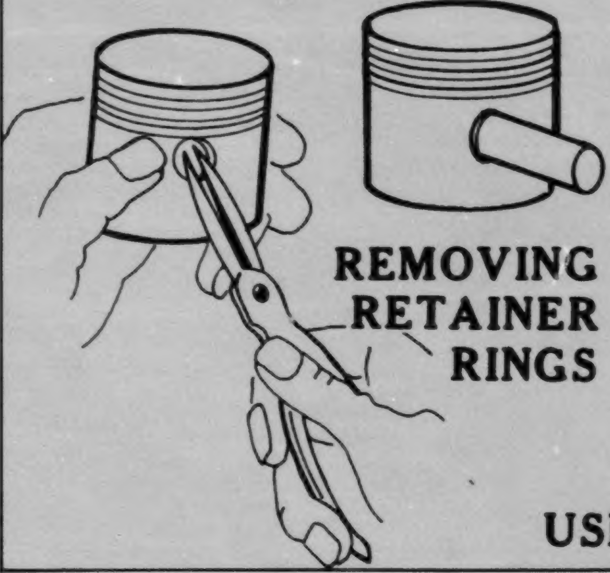

piston
cylinder
flywheel
tapered bearing
timing marks in line on camshaft gears

REMOVING FLYWHEEL

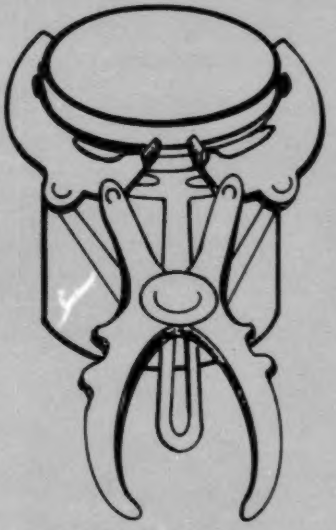

socket wrench
special tool


special wheel puller

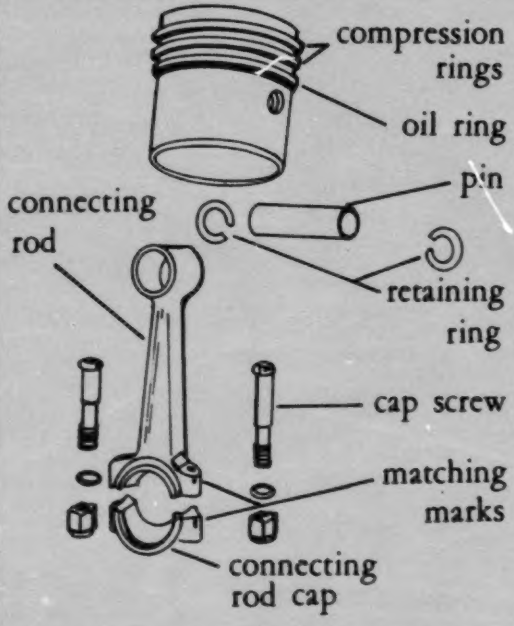
DISASSEMBLING ENGINE



REMOVING RETAINER RINGS



USING RING EXPANDER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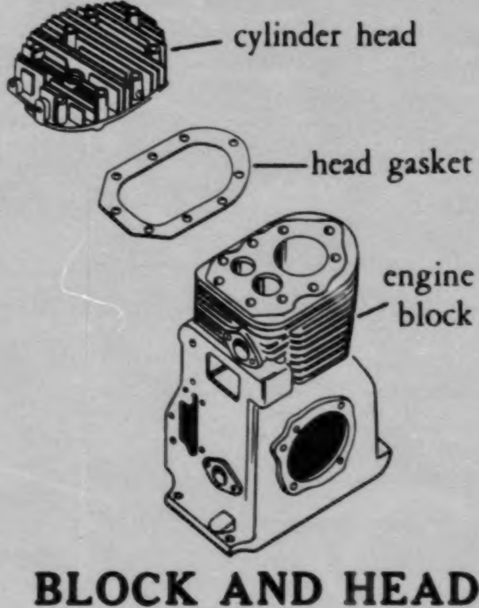
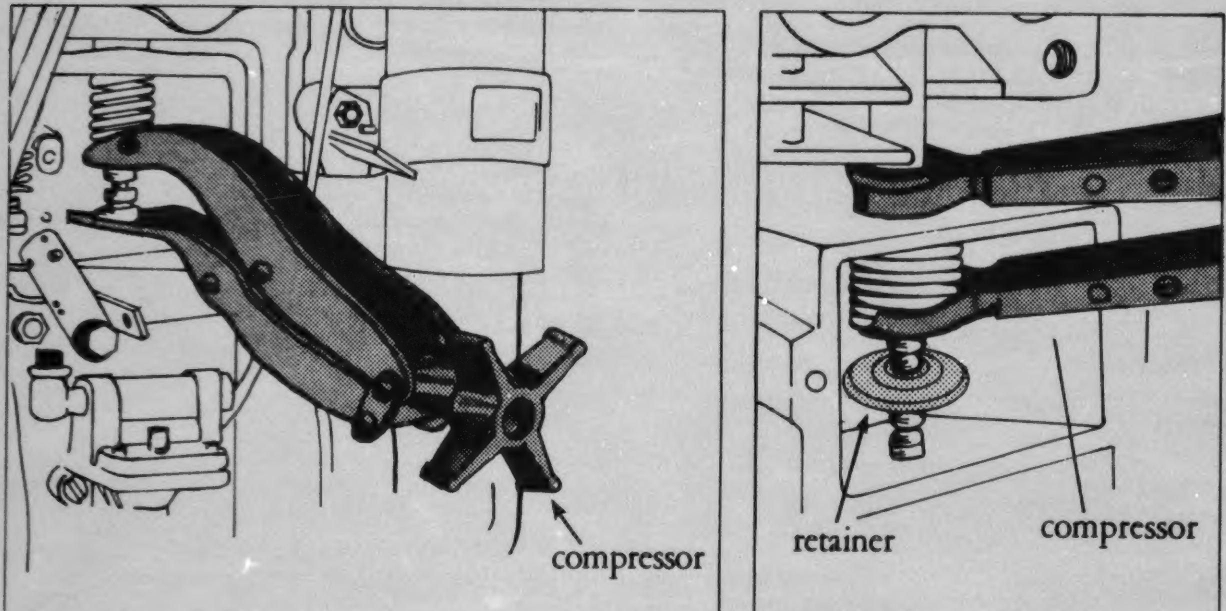
oil ring
pin
connecting rod
retaining ring
cap screw
matching marks
connecting rod cap

PISTON ASSEMBLY

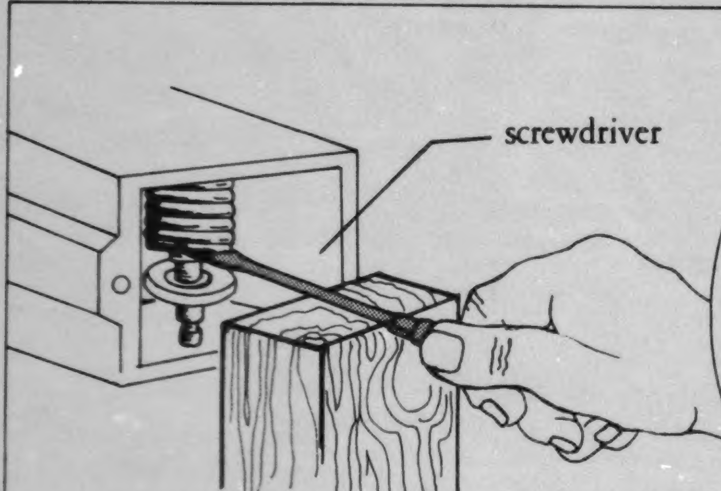

cylinder head
head gasket
engine block

BLOCK AND HEAD UNIT

DISASSEMBLING ENGINE

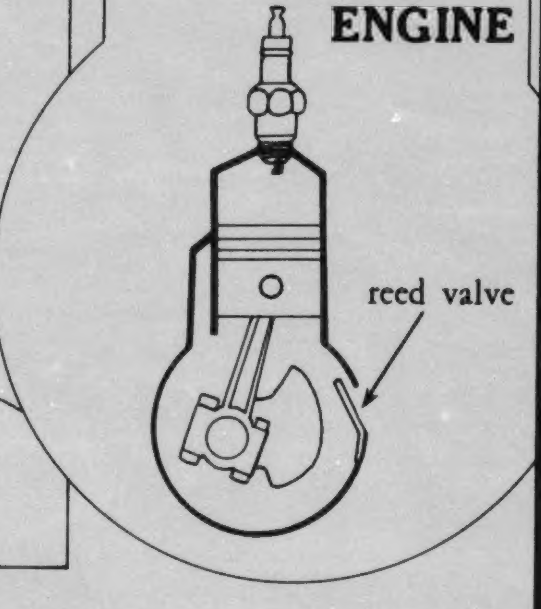

compressor
retainer
compressor

VALVE SPRING COMPRESSORS

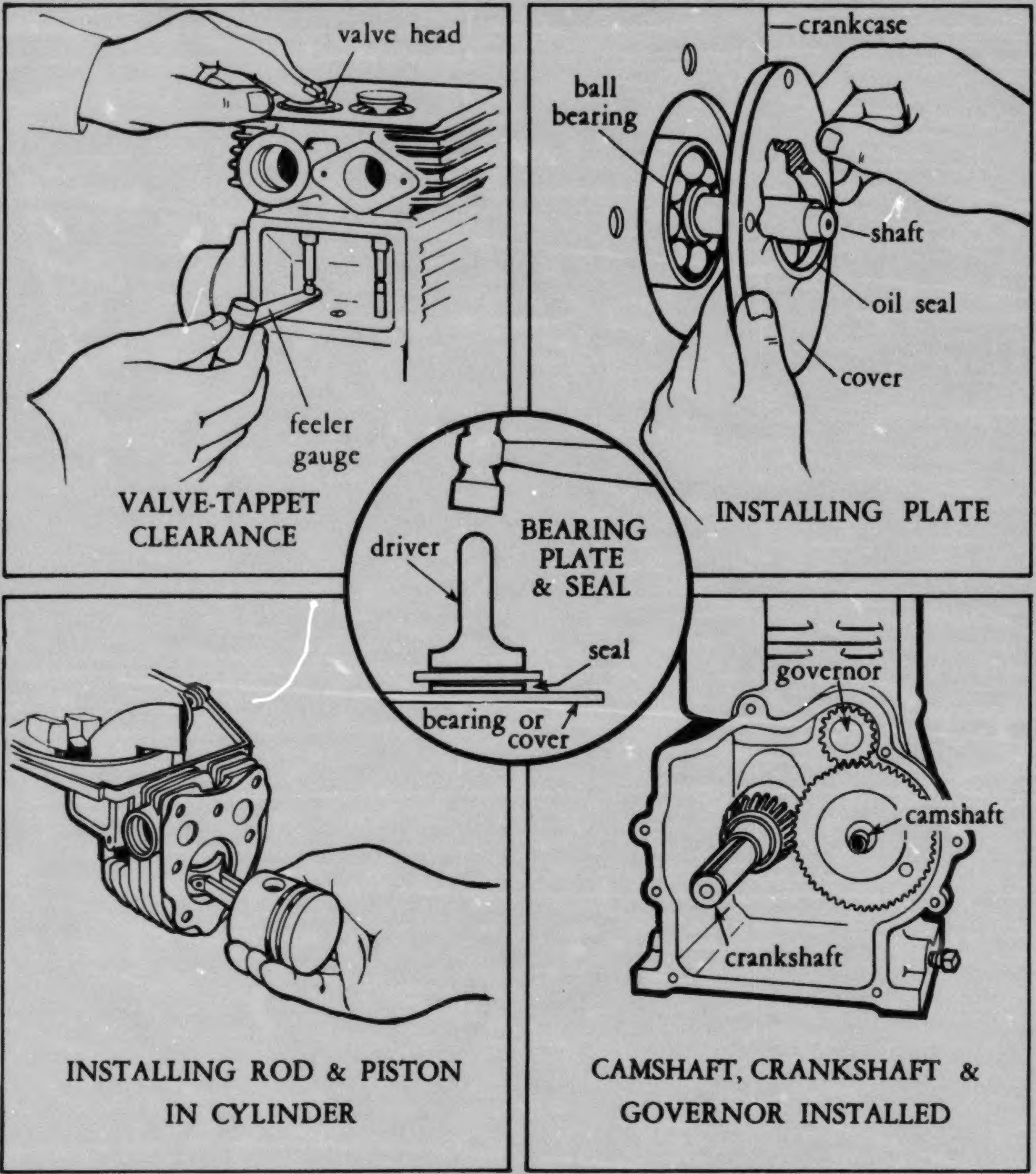

screwdriver

SCREWDRIVER AS SPRING COMPRESSOR

TWO-CYCLE ENGINE



REASSEMBLING ENGINE


valve head
feeler gauge
crankcase
ball bearing
shaft
oil seal
cover
driver
seal
bearing or cover
governor
camshaft
crankshaft

VALVE-TAPPET CLEARANCE

INSTALLING PLATE

BEARING PLATE & SEAL

INSTALLING ROD & PISTON IN CYLINDER

CAMSHAFT, CRANKSHAFT & GOVERNOR INSTALLED

GENERAL AGRICULTURAL MECHANICS

Unit J: Servicing and Repairing Small Gasoline Engines

Topic 3: Checking and Adjusting the Small Engine Carburetor

Suggested Procedures and Activities: The use of two carburetors, one assembled and one disassembled, will serve as excellent teaching aids during the class discussion.

1. The Purpose of the Carburetor

The major function of the carburetor is to atomize fuel (reduce to fine spray), mix air with the fuel, vaporize the fuel, and deliver the mixture to the combustion chamber (that portion of the cylinder where fuel is burned). Usually the fuel-air ratio is considered to be 14 to 15 parts of air by weight to one part of gasoline. Carburetion function is basically the same in two cycle and four cycle engines, in that air is mixed with fuel to form a combustible mixture. The reason that air and atomized fuel flows into a cylinder or crankcase is the difference in the cylinder or crankcase pressure and the outside atmospheric pressure.

Transparency No. 1

2. The Basic Parts of A Carburetor and Their Functions

a. Butterfly or Throttle - The amount of fuel mixture entering the cylinder (combustion chamber) is controlled by the throttle. The amount of mixture admitted determines the engine speed. The throttle also allows the engine to accelerate smoothly from low to high speed.

b. Venturi - The main function of the venturi (narrow part of throttle pipe where accelerated air moves through the carburetor causing fuel to be drawn through the nozzle and atomized) is to increase the velocity of incoming air. Low pressure is created at the fuel nozzle discharge holes due to the high velocity air flow. The atomizing of fuel and mixing with air takes place in the venturi.

c. Choke - The purpose of the choke is to control the air flow into the carburetor. With the choke closed, the air is cut off or greatly reduced and the fuel mixture becomes rich (higher percent of gasoline). A rich mixture ignites and burns readily in a cold engine.

d. Needle Valve - This valve meters the amount of fuel used at operating speed. It also controls the amount of fuel in the carburetor. It is considered to be the high-speed air-fuel mixture adjusting valve. In carburetors that have no needle valve adjustments, the valve is preset by the manufacturer.

e. Idle Valve - This valve adjusts the fuel for slow or idle speeds. It is usually located in the low pressure area of the carburetor (carburetor throat beyond the throttle plate). On some carburetors, idle or slow speed is controlled by a slow-speed-needle valve.

f. Float - A constant fuel or gasoline level is maintained in the carburetor by a float and float bowl. The suction and diaphragm type carburetors are not equipped with a float and float bowl. The float actually controls the flow of fuel from the tank to the carburetor.

Transparency No. 2

3. Methods of Supplying Fuel to the Carburetor

a. Gravity System - The fuel tank is located above the carburetor, thus permitting the fuel to flow by gravity into the carburetor bowl. The float controls the amount of fuel entering the float bowl or float chamber.

b. Suction System - Fuel is drawn from the tank through a tube that is located below the carburetor. The suction created by the engine pulls gasoline from the fuel tank, and a foot valve keeps the fuel from returning to the tank. This insures a tank full of fuel at all times. There are certain types of carburetors with built-in fuel pumps which operate on pressure change within the carburetor. This system is usually found on economy priced equipment.

c. Fuel Pump - The fuel tank on this system is usually mounted at a lower level than a carburetor. The pump pulls the gasoline from the tank and forces it through lines to the carburetor. The fuel pump system is usually more costly than gravity or suction system.

d. Pressurized System - This system is usually found on outboard engines. Fuel can be forced through lines a long distance to the carburetor. There are two lines from the fuel tank to the engine. One line carries gasoline or fuel, and the other carries air from the crankcase to the tank. The fuel tank must be a pressure type for this system to operate.

4. Disassembling, Assembling, and Adjusting an Engine Carburetor

a. Disassembling the Carburetor - The following procedure may be used in disassembling a carburetor:

(1) Use a stiff brush and/or a putty knife to loosen dirt on and around the carburetor. Use an air hose to blow loose dirt and other foreign material from the carburetor and surrounding area. Remove oil and grease by using a solvent and rags. Do not use gasoline as a solvent.

(2) Drain the fuel from the tank and carburetor. If the fuel is perfectly clean, it may be reused.

(3) If an operator's manual is not available or fails to show throttle linkage and carburetor connections, make sketches of the linkage before disassembling. Governor and throttle connections must be reconnected properly.

(4) Use the following procedure to disassemble the float-type carburetor:

(a) Remove the main fuel jet if it is diagonally installed on the side of the carburetor. This jet should be removed before separating the two halves of the carburetor. Use a proper size screwdriver on the main fuel jet (nozzle).
(b) Remove the needle valve by loosening the valve and nut together.
(c) Remove the section bolts of the carburetor together. Mark the gasket(s) so that a new one may be replaced properly.
(d) Pull the pin from the float hinge and remove the float valve. Also remove the idle mixture valve.

If the engine is supplied with a diaphragm-type carburetor, disassemble it in a similar manner as the float-type carburetor. The fuel pump is usually built in this type of carburetor. In disassembling the diaphragm-type carburetor, the diaphragm is removed from the main body of the carburetor.
(e) If necessary remove the choke valve and butterfly from the carburetor.

(5) Disassemble the suction-type carburetor by using the following procedure:

(a) Remove the carburetor from the tank. The broad and shallow tank may resemble a carburetor bowl.

(b) Place the fuel pipe in a vise and pry it out of the carburetor body.

(c) If adjusting needles are present in the suction-lift carburetor, remove them.

After the carburetor has been disassembled, clean all parts with a gum solvent or lacquer thinner. Parts made from synthetics such as nylon should not be soaked for more than 30 minutes. Other parts may remain in a solvent (Bendix, petisol or thinner) for several hours. The engine may be disassembled during the time the carburetor is soaking.

b. After all parts of the carburetor have been cleaned and checked for wear, reassemble in reverse order of disassembly. An examination should be made of the following parts before the carburetor is reassembled:

(1) Needle Valve(s) - If the valve has a worn ring or rim, it should be replaced by a new one with new seats.

(2) Float - The float should be checked for leakage or damage.

(3) Throttle Shaft - The bushing should be replaced if the wear is more than .010 inches.

(4) Fuel Jet - The fuel jets should be cleaned, and if it appears to be damaged, it should be replaced.

(5) Gaskets - All new gaskets should be used when reassembling the carburetor.

There are many types of small engine carburetors. Generally the float-types are similar in design and the suction-types are similar. The suction-type has a built-in fuel pump. The two types of the float-type carburetor are one-piece and two-piece.

c. Carburetor adjustments are made at the factory for normal operation of the engine, but over a long period of usage it is necessary to readjust the carburetor. If the carburetor is reconditioned, it must be adjusted. It is very important that the main needle valve and idle valve be adjusted properly. If the mixture is too lean, the engine will miss and backfire, and if the mixture is too rich, the engine will operate sluggish and produce a heavy exhaust. The following procedure may be used to adjust the carburetor:

(1) Turn the main needle and idle valves clockwise with the fingers until they are tight. Do not use excessive force. Then open the

main needle valve one turn. Also turn the idle valve counterclockwise to open, but make 3/4 turn.

(2) Use the choke and start the engine. Allow it to reach the normal operating temperature.

(3) Operate the engine at normal operating speed, which is about 2/3 full throttle. Turn the main needle valve clockwise until the engine begins to stall or slow down. This means the mixture is too thin. Then turn the main needle valve counterclockwise until the engine begins to stall or slow down again. This needle position means the mixture is too rich. Turn the needle clockwise again to set the needle valve between the rich and lean positions. The engine should operate smoothly.

(4) Adjust the idle valve by turning it clockwise until the engine begins to reduce speed. Then turn counterclockwise until the idle speed is smooth, caused by increased speed of the engine. Set the idle screw at the desired speed. The idle speed can be checked with a tachometer. The idle speed may be considered about one-half the maximum operating speed.

(5) Open the throttle rapidly to check the acceleration. If the engine seems sluggish, turn the main needle valve to give a richer fuel mixture. At this point it may be necessary to adjust the idle speed stop screw. It is adjusted to hold the throttle at the proper speed.

References:

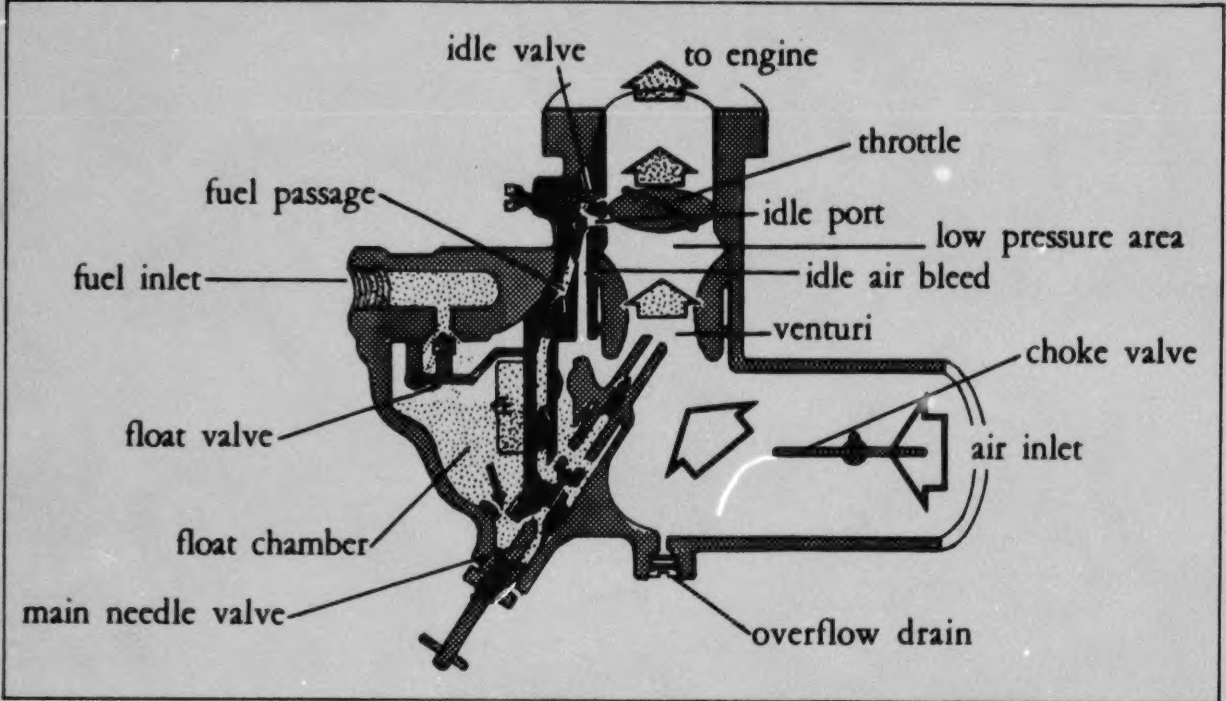
1. Stephenson, George E., Small Gasoline Engines, Delmar Publishers, Albany, New York, 1973

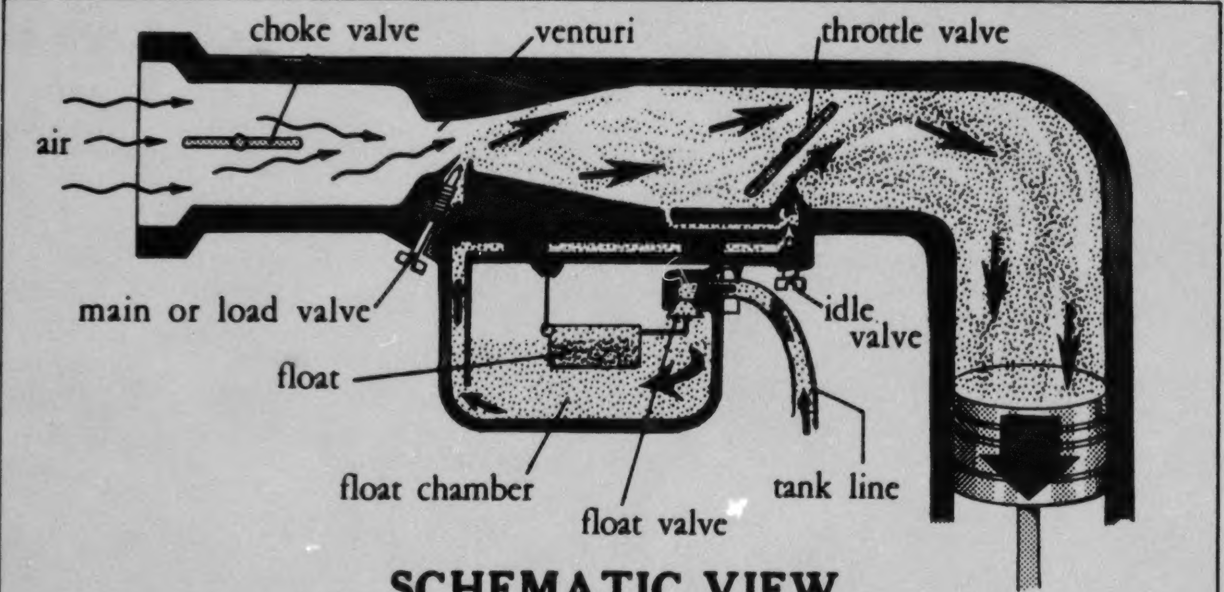
2. "Small Engines - Care and Operation, Volume I", American Association for Vocational Instructional Materials, Athens, Georgia, 1975

3. "Small Gasoline Engine - Float-Type Carburetor Repair", State Department of Education, Columbia, South Carolina, 1973

4. "Small Engines - Repair and Overhaul", University of Illinois, Urbana, Illinois, 1970

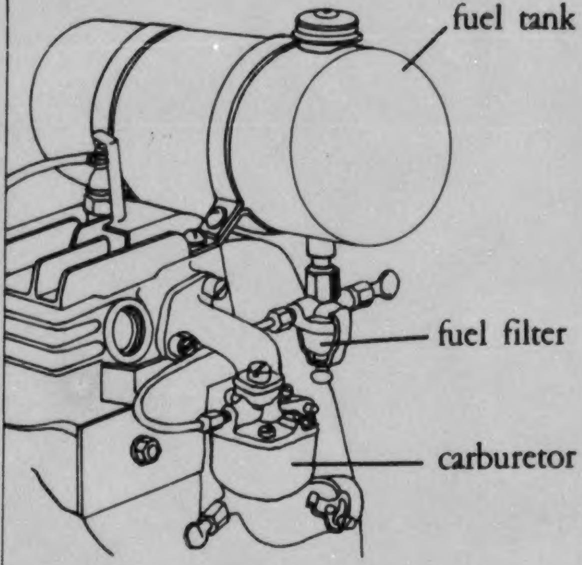
FLOAT TYPE CARBURETOR


idle valve
to engine
throttle
fuel passage
idle port
low pressure area
fuel inlet
idle air bleed
venturi
choke valve
float valve
air inlet
float chamber
main needle valve
overflow drain

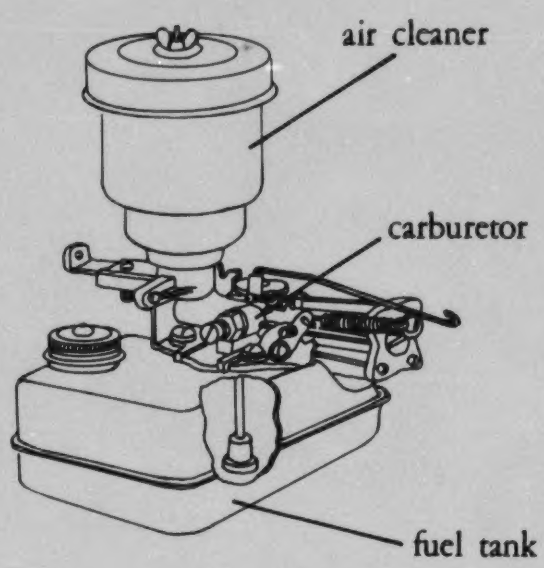

choke valve
venturi
throttle valve
air
main or load valve
idle valve
float
float chamber
tank line
float valve

SCHEMATIC VIEW

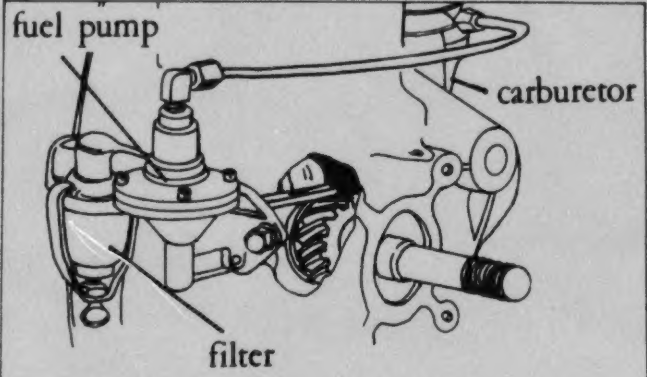
FUEL SUPPLYING METHODS


fuel tank
fuel filter
carburetor

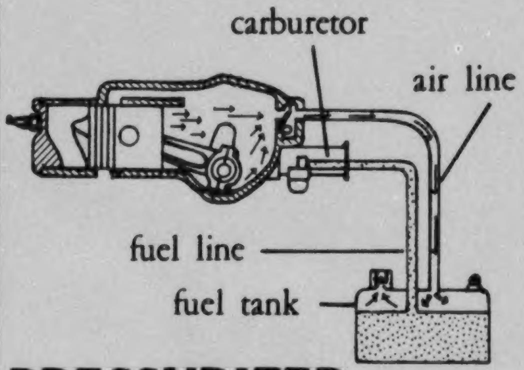
GRAVITY SYSTEM


air cleaner
carburetor
fuel tank

SUCTION SYSTEM


fuel pump
carburetor
filter

FUEL PUMP SYSTEM


carburetor
air line
fuel line
fuel tank

PRESSURIZED SYSTEM

GENERAL AGRICULTURAL MECHANICS

Unit J: Servicing and Repairing Small Gasoline Engines

Topic 4: Checking and Adjusting the Governor

Suggested Procedures and Activities: The operation principles of both the air-vane and centrifugal type governors can be demonstrated by using the governors as teaching aids mounted on the engine and apart from the engine.

1. The Purpose of the Governor

The governor is a speed regulating device to prevent the small engine from either overspeeding or underspeeding. A properly regulated governor will cause the engine to maintain a constant speed with different loads. As the load increases, the governor opens the throttle valve, supplying more air-fuel mixture to maintain a constant speed. The opposite is true when the load is decreased. One part of the governor linkage is attached to the throttle valve, and the part may be located under the flywheel shroud (air-vane type) or on either end of the crankshaft in the crankcase (centrifugal type).

Transparency No. 1

2. Governors Used in Small Engines

   a. Air-Vane Type - This governor is similar to the centrifugal type in that it will automatically adjust the flow of fuel to maintain a set speed. Many brands of small engines are equipped with this type of governor. When the engine is operating, air from the flywheel hits the air-vane, closing the throttle. An increase in speed is caused by an increase in spring tension, and decreasing the speed is caused by decreasing the spring tension on the governor assembly. The throttle is open on a stopped engine with this type of governor, because the air-vane is not pulling against the spring.

   b. Centrifugal Type - The centrifugal type controls speed by the movement of a set of weights. These weights move outward at high speed and inward at low speed. The weights may be either flyball or flyweight types and spool. Outward rotation of the flyweights causes them to push against the spool, which rotates the arm. This causes more spring tension which aids in closing the throttle. Another mechanical governor is the flyball type. It operates on the same principle as the flyweight governor. The steel balls move outward in the spring loaded raceways as the engine speed increases.

Transparency No. 2

3. Checking and Adjusting Governors

a. The following procedure may be used to check and adjust the engine governor:

(1) Check for worn or damaged linkage. A worn lever, link, spring, air-vane, and set screws should be replaced. Slightly damaged (bent) levers and air-vane may be straightened and used if movement is free and proper.

(2) Check the position of the throttle valve when the engine is stopped. The valve should be in the open position. It may be necessary to adjust the spring tension. This is usually done by releasing the tension.

(3) Check the engine speed by using a tachometer after the engine is allowed to warm up. Both no-load idle and high-idle speeds should be checked. The no-load idle speed should be checked with the throttle control in the closed position. The high-idle no-load speed rpm is checked with the throttle control in the open position. The speed should remain constant and at the rpm recommended in the operator's manual. High-idle speeds may vary on a four cycle engine from 2,000 to 3,600 rpm and the speed for two cycle engines vary from about 2,000 to 5,000 rpm. If the engine surges or overspeeds at high-idle, the spring is usually too tight.

(4) Check the full-load engine speed by using a dynamometer if possible. Full-load speed may show 200 to 300 less rpm than high-idle no-load speed.

b. The different ways of adjusting governors include:

(1) Move the spring and/or link on the lever to reduce or increase spring tension. This changes the length of the throttle linkage.

(2) If the governor lever has no adjusting holes, loosen the clamp and rotate it upward or downward.

(3) Some governors are equipped with a throttle link resembling a heavy wire. Bend this link downward to increase speed or bend backward to decrease speed.

(4) On a governor that has a high speed screw, loosen the lock nut and move the screw inward or outward to adjust speed.

(5) Another type of governor control has a governor lever (flat piece of metal) that presses against the governor rod. The lever may be the type that fits into a yoke on one end of the crankshaft and controlled by a variable speed spring or it may be the type lever that is bolted to the casting. Both types press against the governor rod which controls the throttle shaft. To adjust the speed, bend this governor lever up or down.

(6) To adjust the flyweight type, relocate the collars on the shaft.

(7) If the governor is controlled by a lever, spring, and stud, reset the spring on the lever or adjust the stud bolt and nuts for more or less spring tension.

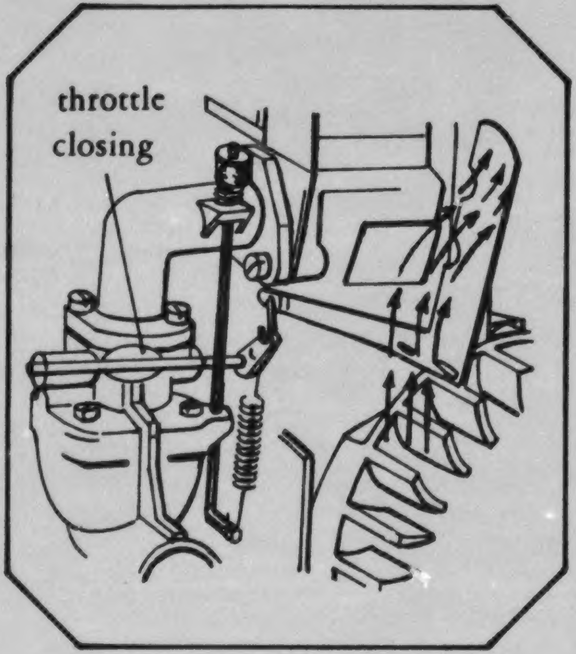
References:

1. "Small Engines, Maintenance and Repair, Volume II", American Association for Vocational Instructional Materials, Athens, Georgia, 1974

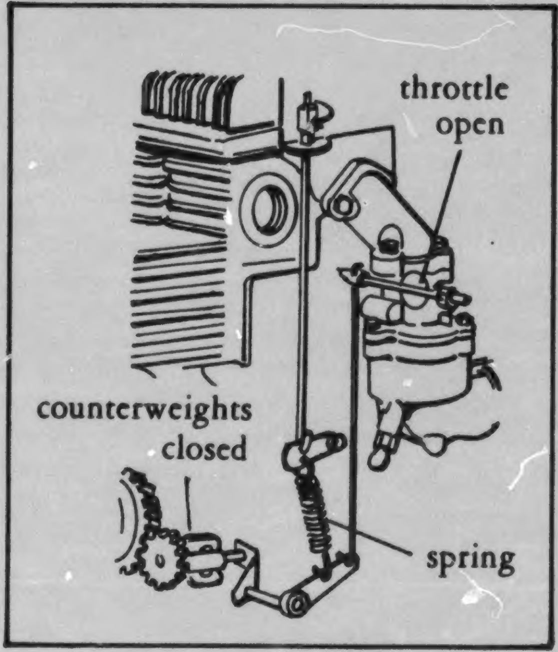
2. "Repair Instruction IV", Briggs and Stratton Corporation, Milwaukee, Wisconsin, 1973

3. "Small Engines Service Manual", Intertec Publishing Corporation, Kansas City, Missouri, 1976

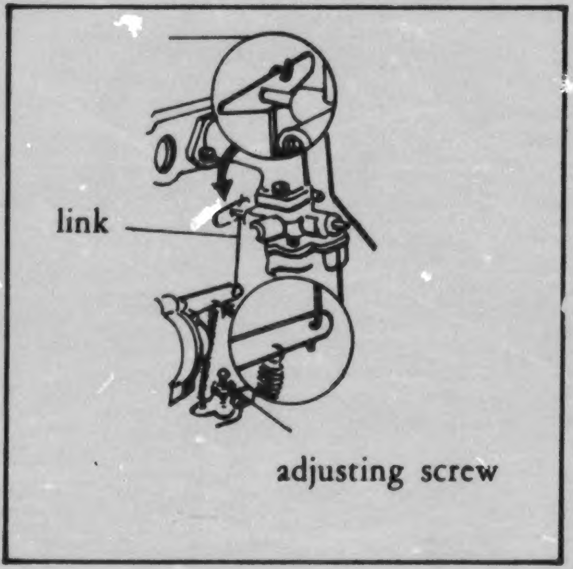
GOVERNORS USED IN SMALL ENGINES


throttle closing

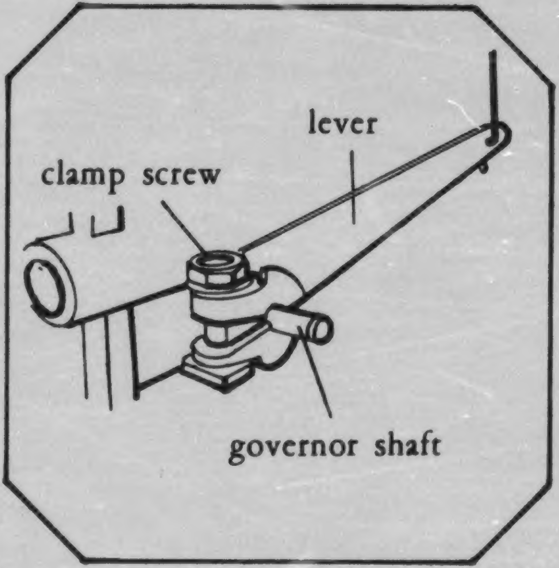
AIR-VANE GOVERNOR


throttle open
counterweights closed
spring

CENTRIFUGAL GOVERNOR

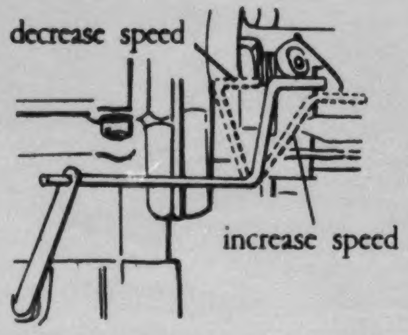

link
adjusting screw

CHANGING LINK

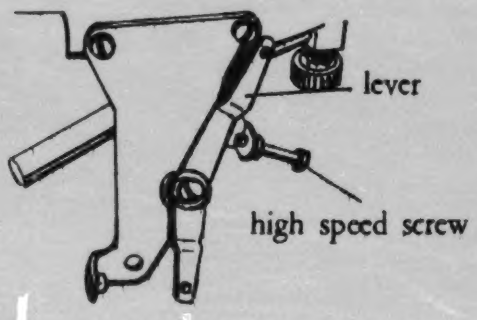

lever
clamp screw
governor shaft

ROTATING LEVER

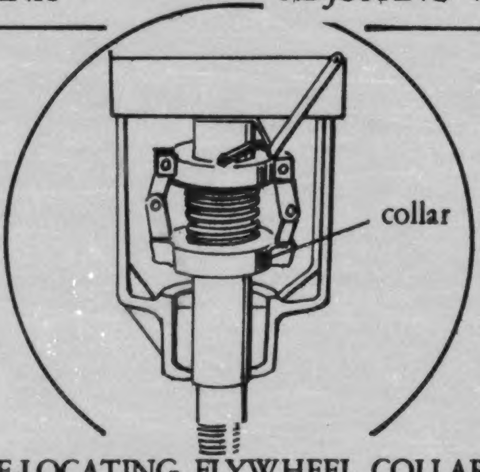
GOVERNORS USED IN SMALL ENGINES


decrease speed
increase speed

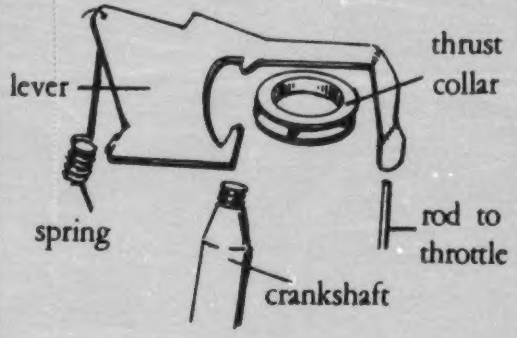
BENDING LINK


lever
high speed screw

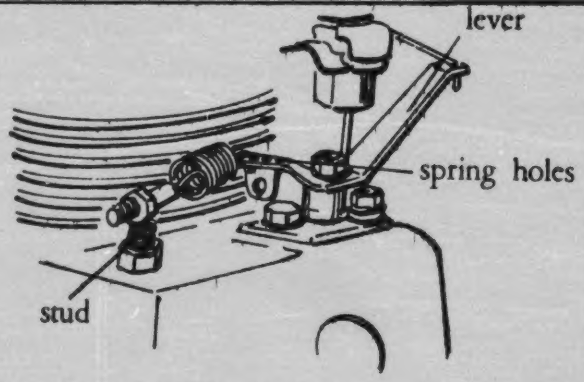
ADJUSTING WITH SCREW



RE-LOCATING FLYWHEEL COLLARS


lever
thrust collar
spring
rod to throttle
crankshaft

BENDING LEVER


lever
spring holes
stud

CHANGING LENGTH OF STUD

GENERAL AGRICULTURAL MECHANICS

Unit J: Servicing and Repairing Small Gasoline Engines

Topic 5: Checking and Adjusting Valves

Suggested Procedures and Activities: If possible use an engine head to show proper and improper valve seating and use several damaged valves during the class discussion.

1. Importance and Functions of Valves

Valves are one of the most important parts of an engine. Without the proper functioning of valves in a four-cycle engine the compression will be low, resulting in the loss of horsepower. They must open and close at the proper time. Each valve opens and closes in about 1/50 a second when the engine is operating at 3000 rpm. One reason valves must open and close (seal well) properly is that they must withstand pressures up to about 500 pounds per square inch.

Heat is another factor affecting valve functioning and maintenance. The exhaust valve is damaged by heat more than any other part of the engine. Valve heads may be heated to 1200 degrees F. in the combustion chamber. The exhaust valve is difficult to cool due to the hot gases passing over it on their way out of the combustion chamber. The incoming air-fuel mixture cools the intake valve. Two-cycle engine valves (piston has a slide valve, reed valve, and rotary valve) control mainly openings from the carburetor to the crankcase. None of these valves are exposed to the same severe heat condition as found in the four-cycle exhaust valve.

When comparing the differences between two- and four-cycle valve operation, it is noted that a high rpm is used to make up for a smaller displacement in the two-cycle engine. The spark advance is considered greater and horsepower-to-weight ratio is higher for the two-cycle engine. Another difference is that the two-stroke cycle plug fires once each time the crankshaft makes a complete revolution (360 degrees), whereas the four-stroke cycle plug fires once each 720 degrees of operation.

Transparency No. 1

2. Parts of a Valve and Valve Assembly

a. The parts of a four-cycle engine valve include: valve head, margin, face, and stem.

b. The valve assembly may include the valve seat, valve port, guide, spring, spring washer, keeper or lock, valve lifter or tappet, and camshaft with lobes.

c. The valve spring holds the valve against the seat. It surrounds the valve stem and when compressed provides tension. Pressure is against a washer and keeper at the bottom of the stem. A cam lobe (thick and high place on the camshaft) causes the valve to open the port by raising a tappet that pushes against the valve stem. Some engines are equipped with valve guides that are located about midway the valve in the block and serve as a support for the valve stem.

3. Valve Failures

a. Burned valve face is a common cause of valve failure. It is usually caused by deposits on the face or burning gases escaping by the face due to insufficient tappet clearance. If the face is burned too deep to leave a proper margin after refacing, it should be replaced. The margin should be not less than 1/64 of an inch.

b. A sticking valve is usually caused by the stem binding in the valve stem guide. Excessive heat around the valve stem area causes oil to oxidize and form a varnish on the stem and guide. Also, there may be deposits of carbon, lead, and gum that cause sticking. Valve burning will result if the valve operates partially open. Fuels that are stored for a long period may have a high gum content.

c. A dished valve is actually warped. It has a sunken or cupped head which causes it to seat improperly. There are several reasons why a valve will become dished. The cause may be too high a temperature, too strong a spring, or eroded valve head caused by highly leaded fuel. Dished valves should be replaced.

d. Necked valves are caused from the same conditions affecting dished valves. The stem just below the head is usually eroded away by excessive heat. If the valve neck becomes red hot, the neck elongates when the head strikes the seat.

e. Valve stem keeper wear is not too common but is found on some valves. If the lower part of the valve stem is badly worn by a keeper it should be replaced.

f. Leaking valves are common on many kinds of small engines, and this condition is caused from burned valves, sticking valves, dished valves, and necked valves. It is also caused from weak or broken springs, warped stem, and burned seats.

Transparency No. 2

4. Removing and Inspecting Valves and Valve Parts

The removal of valves is briefly explained in Unit J, Topic 2. A more detailed explanation of valve and valve parts removal is as follows:

a. After removing the cylinder head from the engine, remove the valve spring cover slip. Place one jaw of the spring compressor on the spring at the tappet end. The other part may be placed on the valve head or the upper end of the spring, depending upon the type compressor used. Force the jaws together and either remove the valve stem pin, stem collars, or retainer washer. A pair of sharp nose pliers can be used to remove the lower stem part. Remove the valve from the engine.

b. Valve springs may be removed or left in place. If the springs are removed, mark each according to its original location. Once the spring is removed, it should be checked with a combination square. Measure its height for length and the ends for squareness.

c. Check both the valve guide and stem for wear. Guide measurement is taken with a gauge and micrometer. Measure the valve stem diameter and compare the two measurements. If the clearance of the valve stem to valve guide is .002 to .003, there is adequate space for expansion and lubrication. Drive the old guide out and press a new guide into place if it is necessary to replace the guide.

d. Most valve seats are cut to a 45-degree angle. A few engines may have seats cut to 30 degrees. Check for pitted or cracked faces and warped heads which may cause partial seating.

5. Lapping Valves

Some small engine manufacturers may recommend that valves be reseated by lapping anytime the engine is disassembled or broken down. A compound of coarse silicon carbide and grease (carborundum paste) is used to face valves. The reconditioning procedure is as follows:

a. Apply a thin layer of coarse-grain lapping compound to valve face. Replace the valve in the proper opening; attach lapping tool to top of valve, and rotate it back and forth applying uniform pressure.

b. Remove or clean away the compound with a solvent and repeat the process using fine grain compound. Clean the valve the second time and apply prussian blue to the face. Insert the valve in the lapped hole and rotate valve with the thumb while applying pressure. A valve properly seated will show bluing to be distributed evenly around the face. Note: the valve must be completely clean before reinstalling it in the engine. A small amount of abrasive compound can damage all moving parts.

Transparency No. 3

6. Adjusting Proper Valve - Tappet Clearance

Recommendations on adjusting the valves may vary with different manufacturers. It may be necessary to install valve springs on some engines before adjusting the valve - tappet clearance, whereas on other engines adjustment is made before installing valve springs. The method used to adjust valve clearance may also vary. A small amount of metal may be removed from valve stem end or the tappets may be adjusted.

On an engine with tappet adjusting screw use the following method:

(1) Use crankcase oil on the valve system (springs, valve, valve guides, and spring retainers). Valves must be clean when making adjustment.

(2) With the valve in the cylinder block turn the crankshaft to top-dead-center on the compression. In this position the valves should be closed and the piston at the top of the cylinder. At this point install the adjusting screw.

(3) Check the operator's manual for valve - tappet clearance and if the valve - tappet clearance is checked with spring in place, compress the proper spring in place and install the retainer locks. Needle nose pliers can be used to install pin-type locks. The retainer lock should be centered on the valve.

(4) Check the valve - tappet clearance by pressing down the valve and measuring the space between the valve and tappet. Adjust the clearance by turning the adjusting screw and tighten jam nuts.

(5) If the engine has no valve tappet adjusting screw, remove the valve and remove the desired amount of metal from the valve end. A

large micrometer can be used to determine the amount of metal removed. Check before grinding the stem and during grinding to determine amount of metal removed. Keep the stem square on the end while grinding. The stem must not be over heated. If the clearance is too short or space too wide, the valve must be refaced and lapped to lower the valve stem.

(6) Reinstall valves in the reverse order of disassembling in the block.

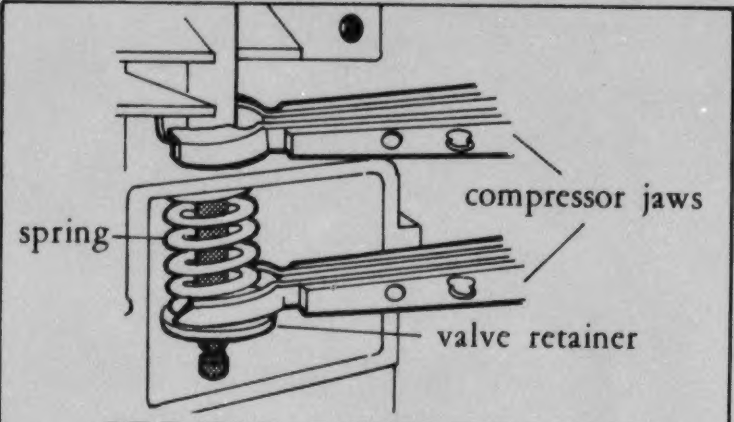
References:

1. Roth, Alfred C., and Ronald J. Baird, Small Engines, The Goodheart-Willcox Company, Inc., South Holland, Illinois, 1975

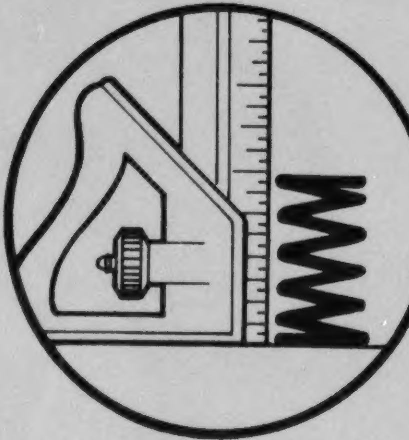
2. "Small Engines, Maintenance and Repair, Volume II", American Association for Vocational Instructional Materials, Athens, Georgia, 1971

3. "Repair Instructions IV", Briggs and Stratton Corporation, Milwaukee, Wisconsin, 1973

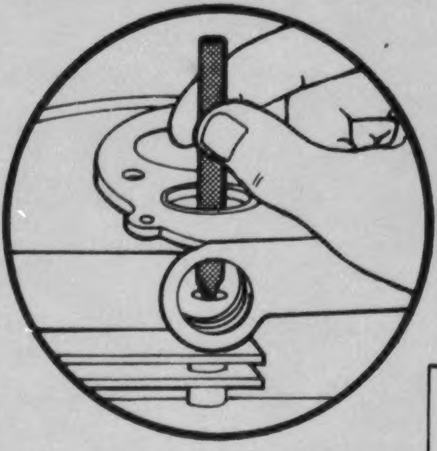
CHECKING VALVES


spring
compressor jaws
valve retainer

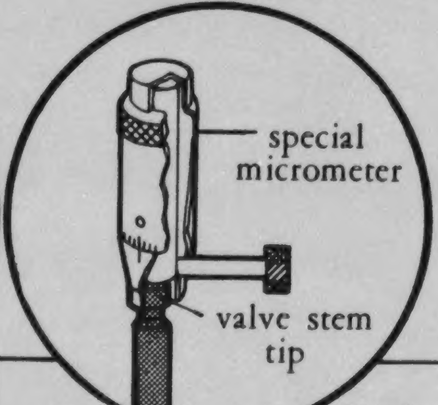
SPRING COMPRESSOR
REMOVING SPRING

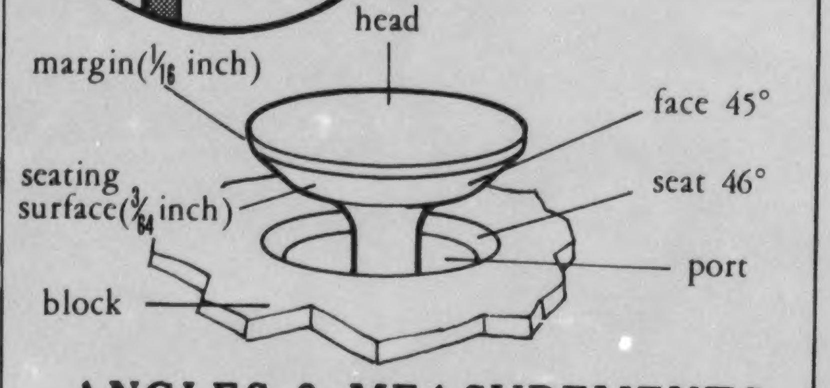


CHECKING
SPRING



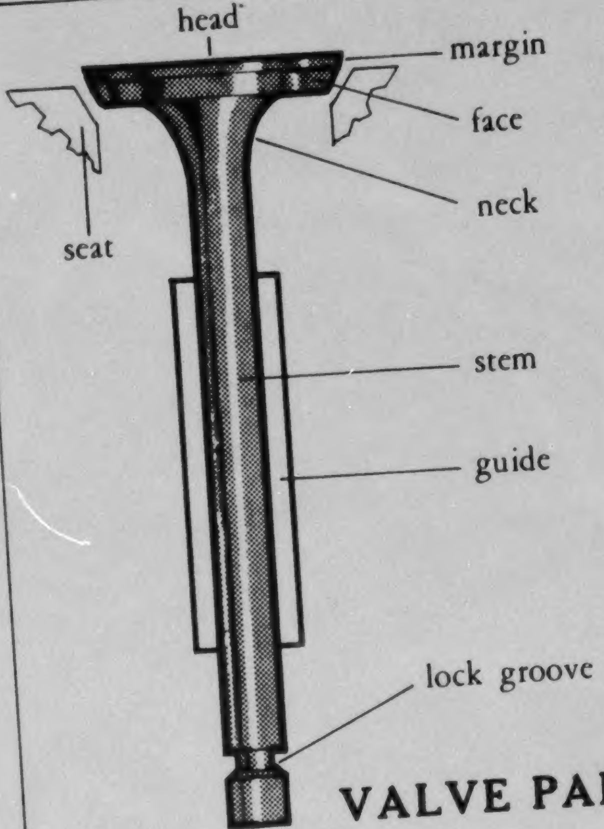
GAUGING
GUIDE


special
micrometer
valve stem
tip

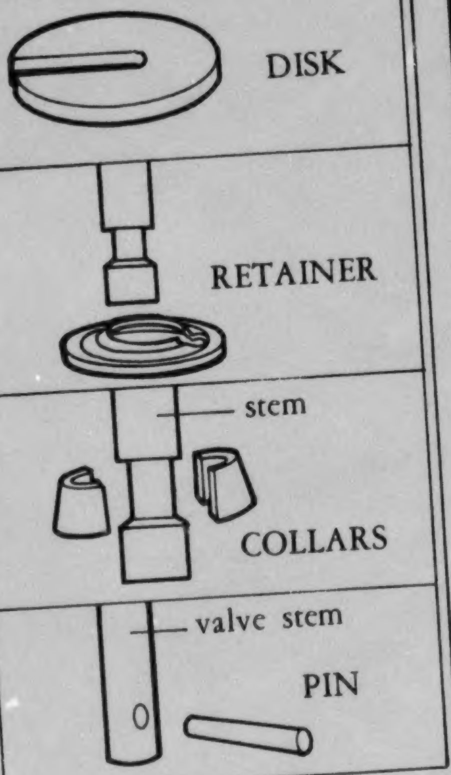

head
margin(1/16 inch)
face 45°
seating
surface(3/64 inch)
seat 46°
port
block

ANGLES & MEASUREMENTS

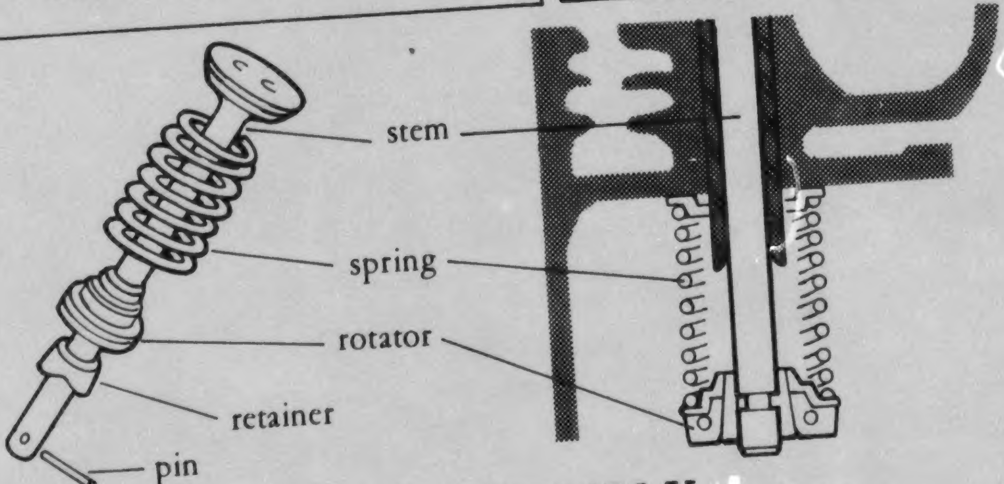
VALVE PARTS


head
margin
face
neck
seat
stem
guide
lock groove

VALVE PARTS

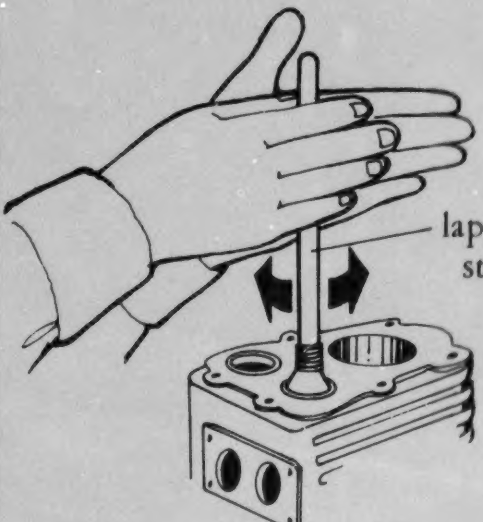

DISK
RETAINER
stem
COLLARS
valve stem
PIN

VALVE LOCKS

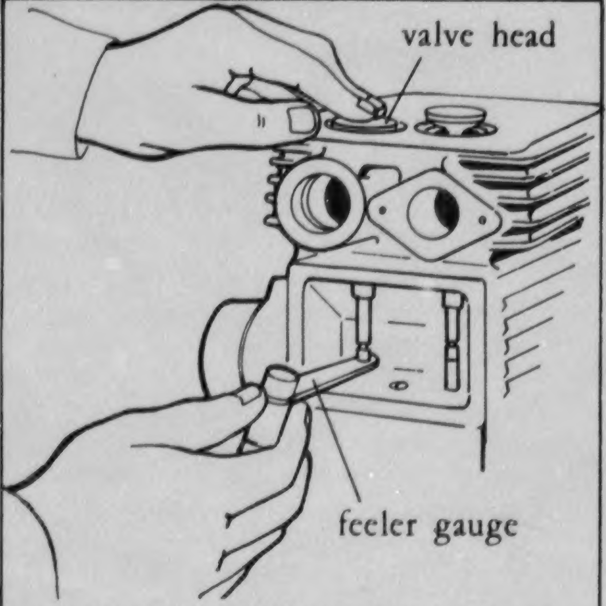

stem
spring
rotator
retainer
pin

VALVE ASSEMBLY

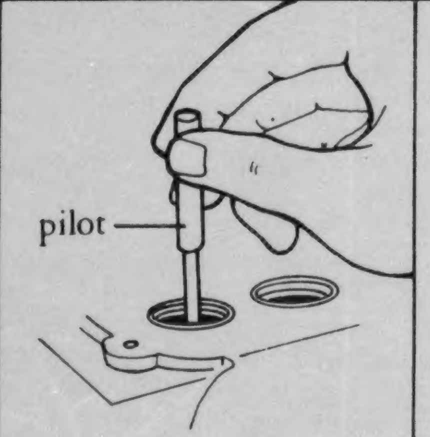
ADJUSTING VALVES


lapping stick

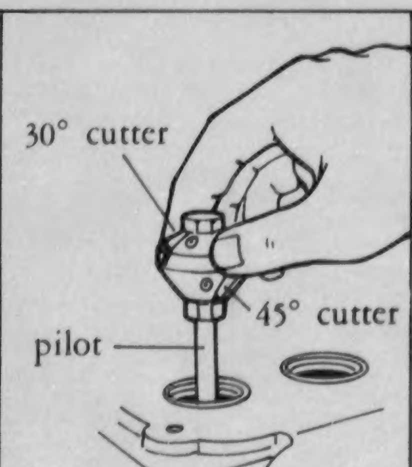
LAPPING VALVE SEAT


valve head
feeler gauge

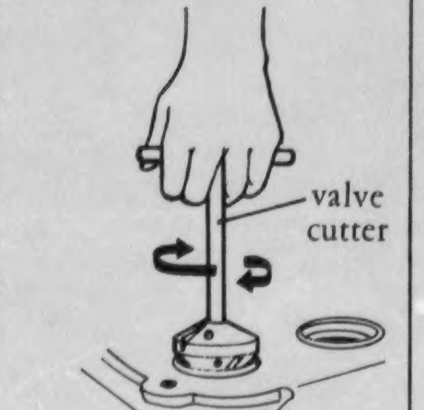
CHECKING VALVE TAPPET CLEARANCE



INSERTING CUTTER PILOT


30° cutter
45° cutter
pilot

CONNECTING CUTTER HEAD TO PILOT


valve cutter

CUTTING SEAT

USING VALVE SEAT CUTTER TO REFACE

GENERAL AGRICULTURAL MECHANICS

Unit J: Servicing and Repairing Small Gasoline Engines

Topic 6: Checking and Adjusting the Electrical System

Suggested Procedures and Activities: Due to most small engines being equipped with magnetos, the use of one as a teaching aid will be helpful during the class discussion.

1. Introduction

The purpose of the ignition system in a small engine is the same as for a large engine. It furnishes a spark at the proper time (just before the piston reaches top-dead-center on the compression stroke) and strong enough to ignite the fuel-air mixture in the combustion chamber. A weak spark may not ignite the fuel, and a spark that is too strong may burn the spark plug electrode.

The three ignition systems found on small engines include the magneto, battery, and solid state.

Transparency No. 1

a. Magneto System - The two most commonly used magnetos are the flywheel and external types. Both types serve the same purposes, to start and operate small engines by properly igniting the fuel. They also produce a very high spark plug voltage (10,000 volts or more). Large engines that require other electrical loads (lights, heating, and cooling) are usually equipped with a different type of electrical system.

Flywheel magnets are imbedded in the flywheel and are not visible from outside the engine. They are made of a special alloy called "alnico" (aluminum, nickel, and cobalt). The external system operates in the same manner as the flywheel system. The main differences in the two systems are: they look different and the external system is attached to the outside part of the engine.

The principle of operation is as follows:

The armature pole pieces are separated from the magneto by a small air gap. The magnetic field is located in the soft iron armature. Lines of force move through the armature coil as the magnet moves past the pole pieces. The coil is made up of a primary winding (several turns of large wire) and secondary winding (many turns of fine wire). Two ends of the primary coil are connected to the breaker points; the other two ends are grounded to the frame of the engine. Current flows through the primary coil as the moving magnets in the flywheel reach the poles with the breaker points closed. When the breaker points open, the magnetic field collapses and lines of force cut through the primary coil for the second time, sending about 100 volts through the coil. The collapsing magnetic field cuts through the secondary coil increasing the current to several thousand volts. A condenser is connected to the primary circuit between the breaker points to prevent excessive arcing between the points and cause the magnetic field to collapse quickly. The most important function of the condenser is to cause a quick collapse of the magnetic field.

Some engines have provision for adjusting the timing whereas others are nonadjustable. Engines that are to be timed have manuals that accompany them giving the degrees or fractions of an inch of piston travel before reaching dead center. The actual timing of the spark is done by having the breaker points open at the proper time. In most engines the breaker points are opened and closed by some type of cam action.

b. The battery ignition system is used on small engines that have starter motors and lights. This system is usually found on garden tractors, riding lawn mowers, and some of the larger stationary small engines. Some small engines may be equipped with both the battery and magneto systems. Usually the battery system has a can-shaped coil that is mounted some place on the engine. The direct current flows from the battery to a coil, from the coil to a distributor, and then from the distributor to the spark plug(s).

Transparency No. 1

c. The solid state ignition system is similar to the flywheel magneto system in that the magnets are located on the flywheel. Actually, they are the only moving parts of the system. This system is different from the flywheel and external systems in current flow to the spark plug. The current passes through the coil to a diode rectifier where it changes from an alternating to a direct current. This direct current passes through a capacitor (works similar to a condenser) after remaining stored until the flywheel makes one-half turn, then it flows directly to the spark plug.

2. Cleaning and Adjusting the Spark Plug

   a. There are three problems that may cause the malfunctioning of a spark plug. Spark plugs may have cracked or broken insulators, too large electrode gap, and be dirty with carbon, sulphur, and oil build up. A cracked insulator is usually caused by the improper use of a spark plug wrench on removal or replacement of plugs. Carbon builds up inside the base and around the electrode. Ground electrode damage is caused by reverse coil polarity. The metal electrode dishes out at the gap of the center electrode. Continuous sparking wears both electrodes.

Transparency No. 2

   b. The method of adjusting the spark plug is as follows:

      (1) Remove the metal connector from the plug, loosen it by using a spark plug wrench, blow or remove dirt from the base, and then finish removing the plug.

      (2) Replace the spark plug wire and ground the threaded plug area to an unpainted part of the engine. Crank the engine and observe the spark. A multi-line blue-orange spark indicates a good plug. The strength of the spark may be checked by removing the wire and holding the metal connector about one-fourth inch from the cylinder head. A more accurate test can be made by using a spark plug tester.

      (3) Clean the plug by using a small-bladed knife to remove carbon and other foreign material from around the center electrode. Clean or file the electrodes by using emery cloth or an electrode file. Wash the plug in a solvent.

      (4) Check the gap with a wire gauge and bend the metal electrode properly. If the gap is too wide, the ignition system may not produce enough voltage for a spark to jump the gap. A flat feeler gauge may be used on a new plug, but a wire gauge is recommended where the ground electrode may be pitted or dished.

gap. The magnetic field is located in the soft iron armature. Lines of force move through the armature coil as the magnet moves past the pole pieces. The coil is made up of a primary winding (several turns of large wire) and secondary winding (many turns of fine wire). Two ends of the primary coil are connected to the breaker points; the other two ends are grounded to the frame of the engine. Current flows through the primary coil as the moving magnets in the flywheel reach the poles with the breaker points closed. When the breaker points open, the magnetic field collapses and lines of force cut through the primary coil for the second time, sending about 100 volts through the coil. The collapsing magnetic field cuts through the secondary coil increasing the current to several thousand volts. A condenser is connected to the primary circuit between the breaker points to prevent excessive arcing between the points and cause the magnetic field to collapse quickly. The most important function of the condenser is to cause a quick collapse of the magnetic field.

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Transparency No. 1

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(6) Not all engines have provisions for adjusting the stator-plate (armature) air gap. This may be referred to as flywheel - to - lamination gap. It is a measurement or clearance between the rotating magnet and laminated iron arms or legs. This method is also used to check the solid state ignition system (air gap measurement between the flywheel and the solid state ignition unit). If the gap is greater than 0.012 inch, the magnetic force lines will be weak in the lamination causing the primary current not to be induced. If the clearance is less than 0.008, the legs (arms) may interfere with the rotation of the flywheel. Use a feeler gauge to check the gap between the flywheel and the two legs. Two other types of stator-plates (armatures) are: stator-plate under the flywheel and stator-plate under the flywheel with magnets mounted in a rotor that turns within the stator-plate.

Transparency No. 3

d. A method used to check the air gap clearance is as follows:

(1) Place a regular postal card between the stator-plate and flywheel. The card thickness should range from .007 to .012 inches.

(2) Rotate the flywheel by hand and check clearance between the card and stator-plate (armature). The rotating magnets should be in line with the armature in order to make air gap adjustment. The stator-plate must be loose for the magnets to pull it against the card on the flywheel.

(3) Tighten the stator-plate and remove the card. A feeler gauge may be used to check the air gap or recheck the gap after a postal card is used. The gauge should be used in areas away from the magnets.

(4) If the stator-plate is located under the flywheel, the flywheel must be removed, a piece of electrician's tape placed on the inner rim, and the wheel turned about a dozen times before removing and checking the tape for scuffing. Scratched or marred tape means the setting is too close. Unmarred tape requires the addition of a second piece using the same procedure, and if the tape is not marred (2 thicknesses) the gap is too wide and the plate must be reset.

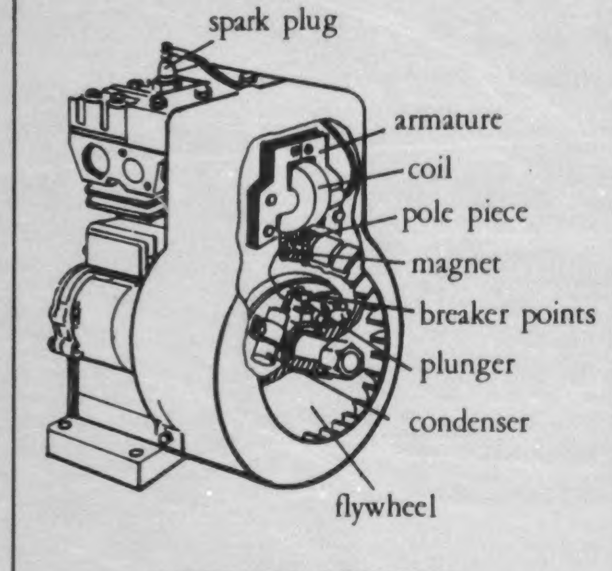
(5) When checking the air gap with the magnet on a separate rotor and under the flywheel, check the gap in four places with a 1/2 inch wide feeler gauge. Turn the crankshaft by hand with the spark plug

removed. If the air gap clearance is too small (below .004 inch) or too large, check the bearings and crankshaft for wear. The stator-plate cannot be moved.

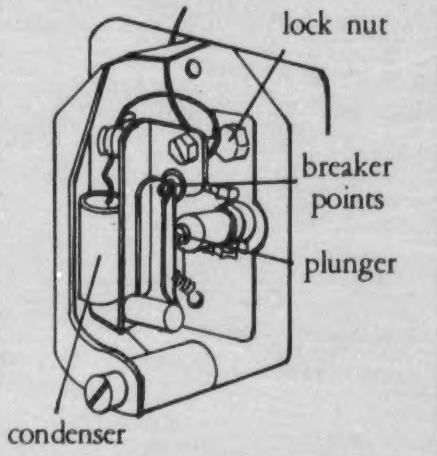
References:

1. "Small Engines, Care and Operation, Volume I", American Association for Vocational Instructional Materials, Athens, Georgia, 1975
2. "Small Engines, Maintenance and Repair, Volume II", American Association for Vocational Instructional Materials, Athens, Georgia, 1974
3. "The Two-Cycle Engine", University of Illinois, Urbana, Illinois, 1970
4. "Repair Instructions IV", Briggs and Stratton Corporation, Milwaukee, Wisconsin, 1973

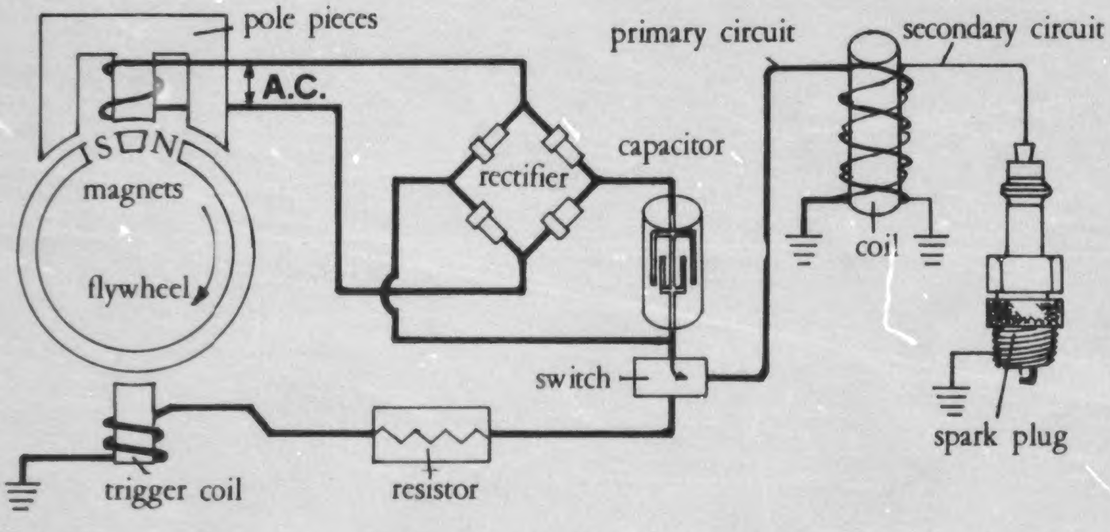
ELECTRICAL SYSTEM
MAGNETO AND SOLID STATE


spark plug
armature
coil
pole piece
magnet
breaker points
plunger
condenser
flywheel

INTERNAL BREAKER

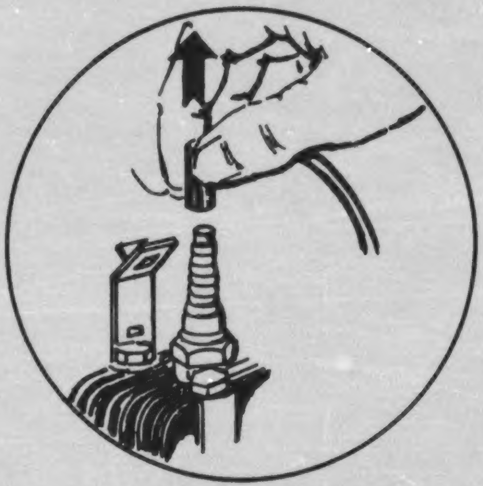

lock nut
breaker points
plunger
condenser

EXTERNAL BREAKER

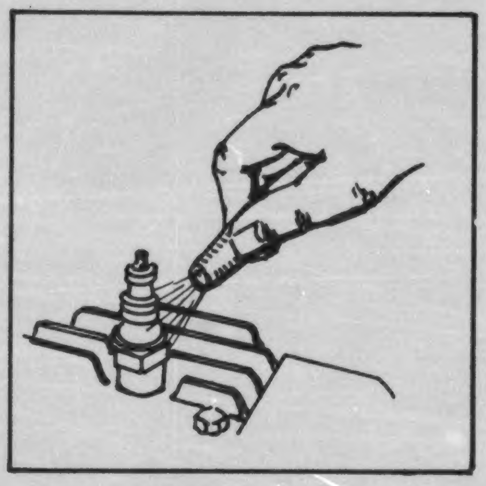

pole pieces
A.C.
S
N
magnets
flywheel
rectifier
capacitor
primary circuit
secondary circuit
coil
switch
trigger coil
resistor
spark plug

SOLID STATE IGNITION SYSTEM - FLYWHEEL MAGNETO

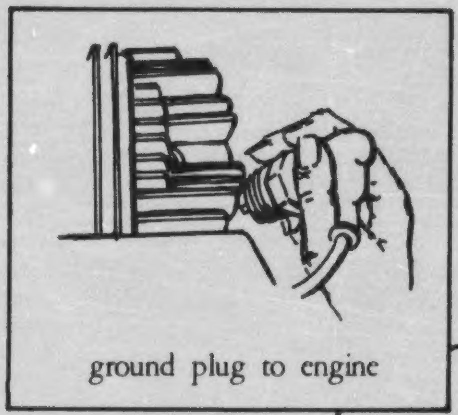
ELECTRICAL SYSTEM
SPARK PLUG MAINTENANCE



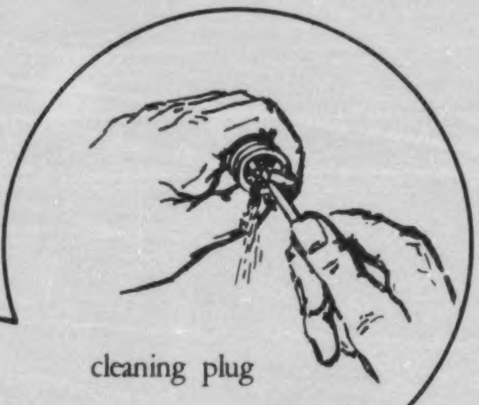
removing metal connector



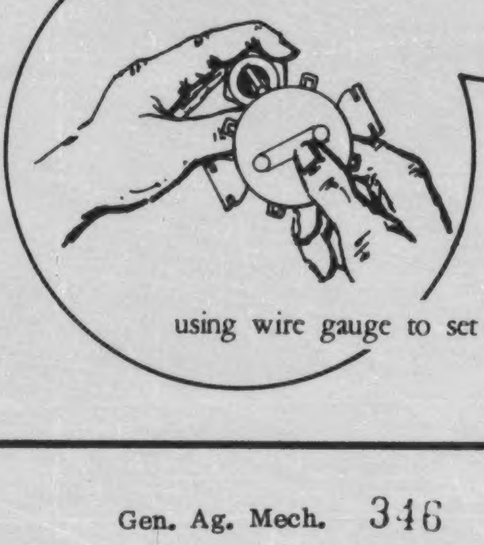
cleaning plug area



ground plug to engine

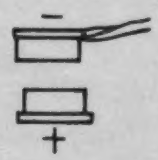


cleaning plug

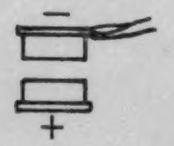


using wire gauge to set gap

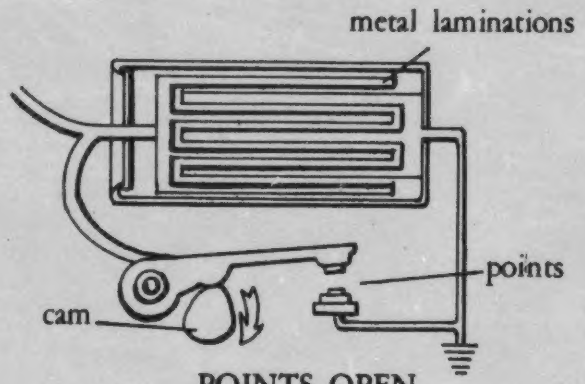
ELECTRICAL SYSTEM ADJUSTMENTS



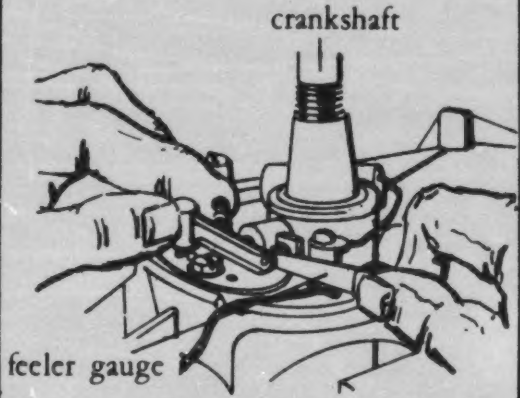
POINTS OUT OF LINE



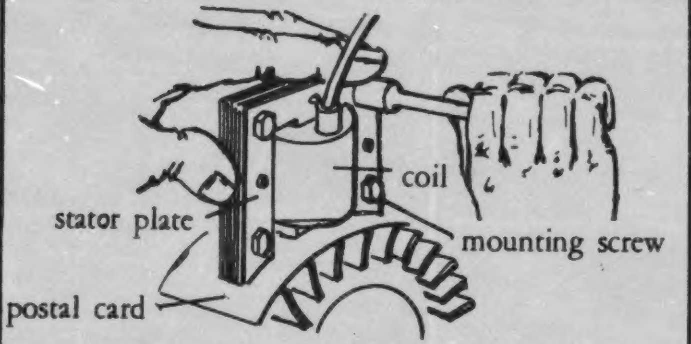
POINTS IN LINE


metal laminations
points
cam

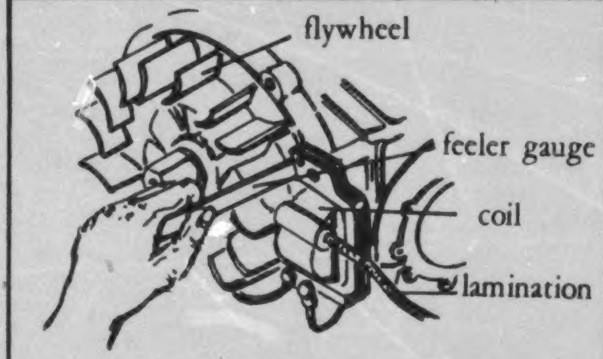
POINTS OPEN


crankshaft
feeler gauge

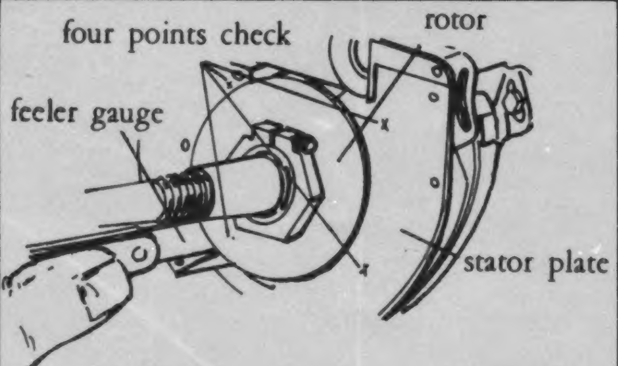
ADJUSTING GAP


coil
stator plate
mounting screw
postal card

ADJUSTING AIR GAP


flywheel
feeler gauge
coil
lamination

CHECKING AIR GAP BETWEEN LAMINATION & FLYWHEEL


four points check
rotor
feeler gauge
stator plate

CHECKING AIR GAP ON MAGNA-MATIC SYSTEM

GENERAL AGRICULTURAL MECHANICS

Unit J: Servicing and Repairing Small Gasoline Engines

Topic 7: Inspecting and Repairing the Cylinder and Piston

Suggested Procedures and Activities: An engine block and piston assembly can be used as teaching aids during the class discussion.

1. General Information

Some of the main causes of an engine having poor compression are due to a worn cylinder, worn piston rings, and worn pistons. There are two types of cylinder units found in small engines. The most common type is the one-piece integral cylinder block plus the crankcase. The less common type is the separate cylinder block bolted to the crankcase.

2. Inspecting the Cylinder and Making Adjustments

Transparency No. 1

a. Check for a ridge ring at the top of the cylinder. The thickness of the ridge may be checked by using a micrometer. Remove the ridge before the piston is removed. Cut the ridge even with the piston wall by using a ridge removing tool. It will be necessary to rebore the cylinder if the wall is cut too deep. If there is no ring, the piston can be removed easily through the cylinder top.

b. Cracks or heavy scar marks will normally require the reboring of a cylinder. If reboring is necessary, take the block to a machine shop that has boring equipment. Heavy scar marks can cause loss of compression and oil. If the marks are too deep for oversizing, replace the block. A cracked cylinder should be replaced. A cracked cylinder will leak oil and lose compression. Some conditions causing scarring are: overheating, lack of lubrication, and incorrect piston clearance.

c. Broken fins may cause hot spots on the engine. In that they cannot be repaired, replacement may be necessary. Stripped bolt holes can be repaired with thread inserts; therefore, block replacement is usually not necessary.

Transparency No. 1

d. Carefully measure each cylinder diameter with an inside micrometer. Compare the original factory cylinder diameter with the current measurements to determine whether or not the cylinder has been rebored and the amount of reboring which was done. The diameter at both top and bottom of ring travel can be determined by using a telescoping gauge. Taper can also be determined by measuring ring end gap at both top and bottom of the cylinder. The difference between the two measurements is divided by π which is a difference in circumference.

Transparencies Nos. 1 and 2

e. Check the cylinder for out-of-round by using a telescoping gauge. The cylinder is checked at right angles to the crankshaft and parallel measurements to the crankshaft. Compare the parallel measurements with the right angle measurements at the top and bottom ring travel zones in the cylinder bore (parallel top with right angle top). If excessive out-of-roundness (.005 inch or more) or taper is present, the cylinders must be rebored. Minor taper and out-of-roundness may require only deglazing. The two major types of deglazers are the ridge and flexible. Both types leave a cross pattern on the cylinder wall that provide cavities for holding oil during piston break-in. After a cylinder is rebored (first time .010 of an inch and second time .020) it is deglazed or honed. This repair job is accomplished by using an abrasive tool mounted in an electric drill. The honing tool is moved up and down in the cylinder. It should remain far enough in the cylinder so that the guides and stone can be kept straight and steady. Adjust the stone against the cylinder walls loose enough that it can be turned by hand. Usually, it is advisable to cut the bottom of the cylinder first. Remove the stone and measure the size of the cylinder from time to time during the honing process. It is advisable to change to a fine stone when the cylinder is within .002 of the desired bore. After a cylinder has been deglazed it is very important that it be perfectly cleaned. However, it is not advisable to use gasoline, kerosene, or commercial cleaners to clean cylinders. These solvents will not remove abrasions from the walls. Use soap and water followed with 10 weight oil and several clean rags to clean reconditioned cylinders.

f. There are two types of cylinders that cannot be rebored. They are: chrome plated aluminum and cylinders formed by a flanged sleeve. Solid cast iron and cast-in-sleeve types can be rebored.

Many shops are not equipped with reboring equipment; therefore, it may be necessary to diagnose to rebore condition and have the work performed by a shop that is equipped for such jobs.

g. When removing cylinder sleeves a special sleeve puller is required to remove sleeves or liners. Most sleeves can be removed at room temperature unless the liners are completely frozen to the cylinder walls. A good penetrating oil or solvent may be used to advantage. In some cases heat is used to help free the liner before it is pulled. To properly install a sleeve, the counterbore area should be clean and the liner must fit perfectly on the bore to prevent distortion; therefore, it is necessary to clean all carbon deposits from under the flange of the liner and mating bore. In some cases it may be necessary to shim the liner to bring it to a proper height or to the manufacturer's specification.

Transparencies Nos. 2 and 3

3. Pistons and Piston Service

The main jobs of pistons are to take the force of combustion and transmit it to the crankshaft. They also carry the piston rings that seal and clean the cylinders.

a. Pistons are made up of the following parts: head, skirt, ring grooves, piston pin boss, and lands. The purposes of the parts are:

(1) The piston head receives the pressure exerted by the combustion gases. The top of the head may be concave, flat, or irregular.

(2) The skirt is located below the ring grooves. It helps keep the piston in alignment. It is elliptical in shape and tapered.

(3) The ring grooves are cut around the piston to hold the rings. The ring grooves are different in sizes. Usually the lower and wider groove has openings that permit the oil to flow back from the oil control ring.

(4) The piston lands are the metal ridges between the ring grooves that support or hold the rings in place.

b. Cleaning pistons and checking ring grooves are very important steps in piston repair. Remove the rings from the piston by using a ring removing tool and place the piston in a carbon removing solution. Rinse the piston and let it dry. Mount the piston in a vise by clamping the connecting rod just below the skirt. Examine and service grooves in the following ways:

(1) Clean carbon from the grooves with a ring groove cleaning tool or

broken piston ring. Examine the grooves for side wear, dents, and burns. Check the compression groove for wear because most of the ring wear occurs at this ring location.

(2) Check groove widths with a new ring and feeler gauge. If side clearance is more than .008 inch, excessive wear is present. Clearance may vary from .002 to .007 inches. The manufacturer's specifications will give the proper measurements. Grooves do not wear evenly, so they should be checked in several places. Special gauges are available for checking grooves.

(3) If the ring groove needs to be reconditioned, cut the groove wider and install a steel spacer above the new piston ring. There are both manual and power driven tools used to recondition grooves. If the top ring groove is not repaired, it may cause the piston to be damaged and fail, which in turn will cause other parts of the engine to be damaged and fail.

(4) Check the piston for cracks, scuffing, scarring, and burning.

- (a) Check all pistons for signs of cracking. Cracks may be found around pin bosses and piston skirts. Do not use a piston that shows any signs of cracking.
- (b) Scuffing and scarring may be caused by the lack of proper lubrication, improper warm up, clogged cooling system, preignition, and overloading. Reject a badly scarred piston.
- (c) Preignition usually is the cause of burning. This condition may be corrected by proper fuel mixtures, proper timing, and tightening the spark plugs. Discard any piston that has a badly burned top. Usually if a piston is severely burned a hole will appear in the top.

(5) Check and correct the following physical condition or conditions that cause damage to pistons: connecting rod out of alignment, too much crankshaft play, taper on the crankshaft journal, cylinder bore out of alignment, and faulty piston pins.

c. To resize and fit the piston use the following procedure:

The piston may be placed in the cylinder bore where it will be used. One method of checking the piston for size is to invert it and place it in the bore. A feeler gauge or spring scale may be used to check the clearance (.005 to .010 inch in some engines) between the piston and the bore wall. It may be necessary to resize or expand the piston to fit the cylinder. If a new piston is too large, it is shaved until the size is correct. The piston may be knurled with a wire brush or knurling tool to increase the size. The thrust areas of the skirt are made larger by knurling. Spring skirt expanders are also used to enlarge the skirt size. The inside measurement of the bore and the outside measurement of the piston is another way to check clearance.

d. Check the piston pin to be sure that it fits tightly enough to prevent pin knock, yet be loose enough to be sufficiently oiled. The pin hole must be perfectly straight, smooth, and free of taper. Check the pin fit by clamping the connecting rod in a vise and rocking the piston back and forth. If the hole is tapered or the pin does not fit properly, the movement should identify the need for adjustment. The piston-pin bore can be checked with an inside micrometer and gauge. An outside micrometer is used to check the pin.

Transparency No. 4

e. The piston pin is installed by first installing a lock ring in one pin opening on the piston. If needle bearings are used, they can be held in place by coating them with heavy grease. Oil the rod bearing and piston bore. Place the rod bearing in line with the pin holes in the piston and insert the pin. If the pin is a little too large, heat the piston to expand the holes and place the pin in dry ice before trying to install it. Install the second pin lock ring after installing the pin. Types of pins are: fixed, semi-floating, and floating.

Transparency No. 4

4. Piston Rings

a. There are two types of piston rings, compression and oil control. The compression rings exert pressure on the cylinder wall to compress the fuel mixture into a small space and prevent gases from passing by the piston during the compression and power stroke. The oil control ring is usually located below the compression and power stroke. This ring is usually perforated or slotted to allow oil to be spread over the cylinder wall and to wipe excess oil from the wall.

Various shapes of piston rings are used in tractors. Some of the more common shapes are: rectangular, barrel-face, inside bevel, taperface, and keystone.

The most common ring joints are step, angle, and straight. The straight joint is the most widely used of the three.

b. When installing it is advisable to follow the installation directions that are furnished with each set of rings. If the cylinders have been rebored, a rebore set of rings should be used. Otherwise, an oil control set is adequate. The steps for installing rings are:

(1) Place the ring inside the cylinder where it is to be used. Push it to the bottom of the ring travel with an inverted piston. Measure the ring gap while it is in this position. Allow .003 to .004 inch gap per inch of cylinder diameter. Use a feeler gauge to take the measurement. The gap allows for heat expansion and facilitates placing the ring on the piston.

(2) The proper ring side clearance is important; therefore, place the ring in the ring groove and roll it around the piston. If the ring does not move freely around the groove, it may bind on expansion, thus keeping it from sealing, which will cause a blow-by. Check the ring clearance with a feeler gauge with part of the ring in the groove.

(3) Place the bottom oil ring on the piston and continue to work up until all rings are installed. If a multiple type oil ring (expander and rails) is used, all gaps should be at least one inch apart. Use a ring expander to place the rings in the proper groove turned the right way.

Transparency No. 5

5. Connecting Rods

The connecting rod of an engine must be light and strong. It transmits the thrust against the piston to the crankshaft. The rod parts are the cap, head, shank, and eye. The cap, head, and eye contain bearings or inserts. The head is connected to the crankshaft journal and the eye to a piston pin.

a. It is important that the engine connecting rods be checked because it is customary to reuse the rods in an engine after overhauling it; therefore, they should be thoroughly examined and adjustments made before the engine is assembled. The rods are checked in the following manner:

(1) Check the rods for twist and bend. Twisting causes the centerlines of the upper and lower bores to be out of alignment. A bend will cause the upper bore to not be parallel to the lower bore.

It is recommended that a twisted or bent rod be replaced with a new one.

(2) Check the crankshaft bore for roundness on some engines. Use a telescoping gauge and a micrometer to take measurements with the cap torqued. Out-of-roundness should not exceed more than .001 inch. Inside measurements should be taken in several locations. To correct out-of-roundness, a special grinder is used to remove metal from both the upper and lower parts of the bore. After the metal is removed, the cap is replaced and torqued. Remove rough stock by honing and recheck for roundness and size.

Transparency No. 5

6. Installing Rod and Piston Assembly

The steps to follow in assembling the connecting rod and piston are:

a. After checking the entire rod and piston assembly, lubricate the piston, piston pin, rings, and other parts. Clean the bore with a cloth. Do not use a solvent.

b. Place a piston ring compressor over the rings and tighten. With the piston head turned upside down, push the compressor on the piston evenly and finish tightening. After the compressor is drawn up tight, loosen it slightly. Place the connecting rod and piston with rings compressed into the cylinder in the proper position. Push the piston down into the cylinder. This step removes the ring compressor.

c. Remove the rod cap and wipe excess oil from the crankshaft and insert. Place the connecting rod over the crankshaft crankpin, and replace the rod cap and screw locks after putting a strip of plastigage across the insert. Tighten the rod cap with a torque wrench using recommendations from the service manual. Remove the cap and measure the plastigage at its widest point using the plastigage scale. The proper clearance is indicated by the number corresponding to the width of the plastigage. The plastigage is removed and the cap torqued. The proper side clearance is also important; therefore, the manufacturer's specifications should be followed when taking this measurement.

It is a good practice to record measurements when disassembling and assembling an engine.

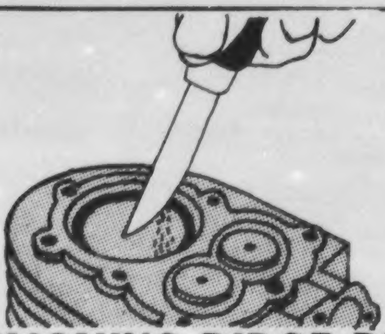
References:

1. Roth, C. Alfred and Ronald J. Baird, Small Engines Fundamentals, Service, Troubleshooting and Repairs, The Goodheart-Willcox Company, Inc., South Holland, Illinois, 1975

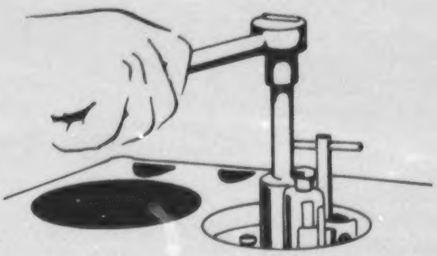
2. "Small Engines Maintenance and Repair, Volume II", American Association for Vocational Instructional Materials, Athens, Georgia, 1974

3. "Repair Instructions IV", Briggs and Stratton Corporation, Milwaukee, Wisconsin, 1973

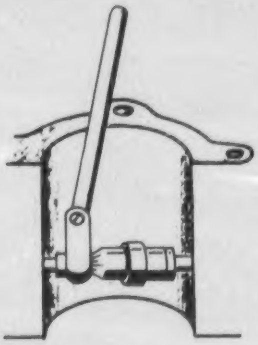
REMOVING RIDGE & CHECKING CYLINDER



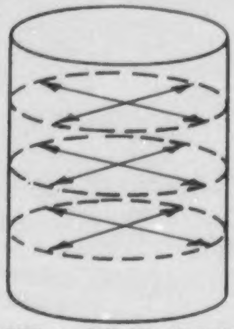
REMOVING RIDGE RING



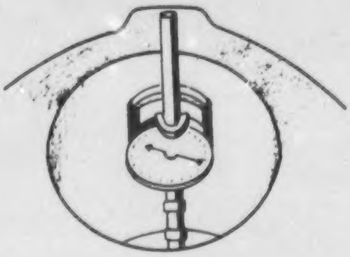
REMOVING RIDGE



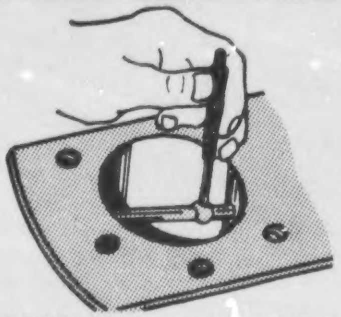
INSIDE MICROMETER



SIX MEASUREMENTS IN CYLINDER

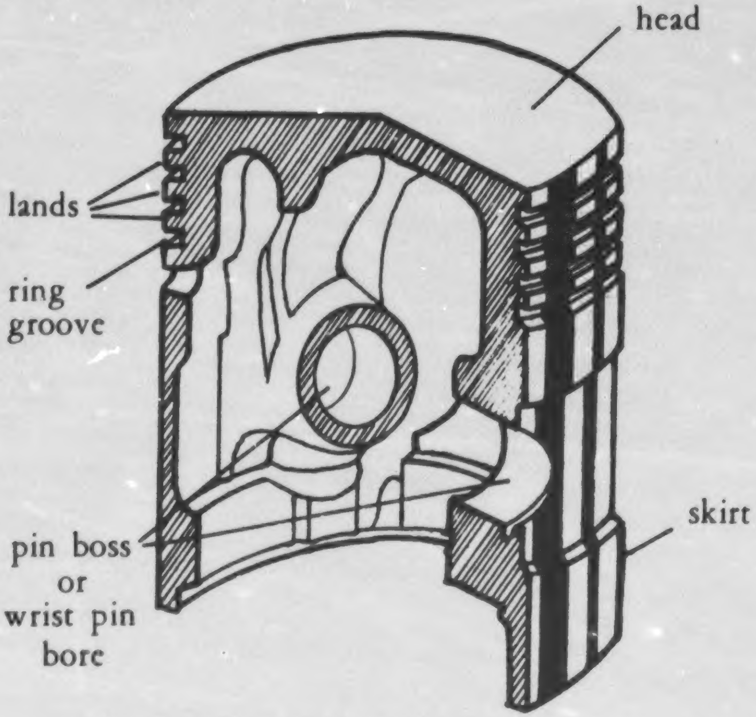


TAPER GAGE

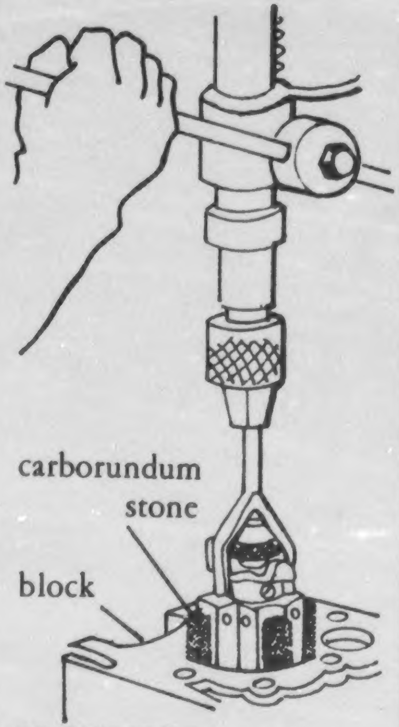


MEASURING CYLINDER SIZE OUT OF ROUND

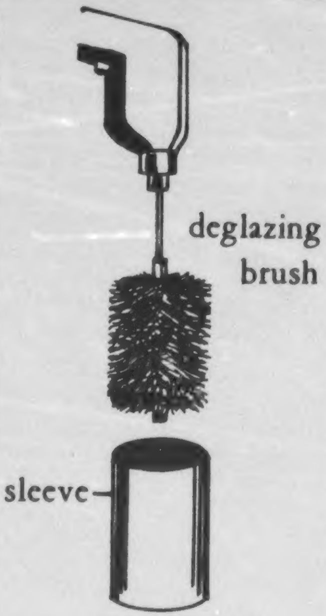
PISTON PARTS & DEGLAZING CYLINDER


head
lands
ring groove
pin boss or wrist pin bore
skirt

PISTON PARTS

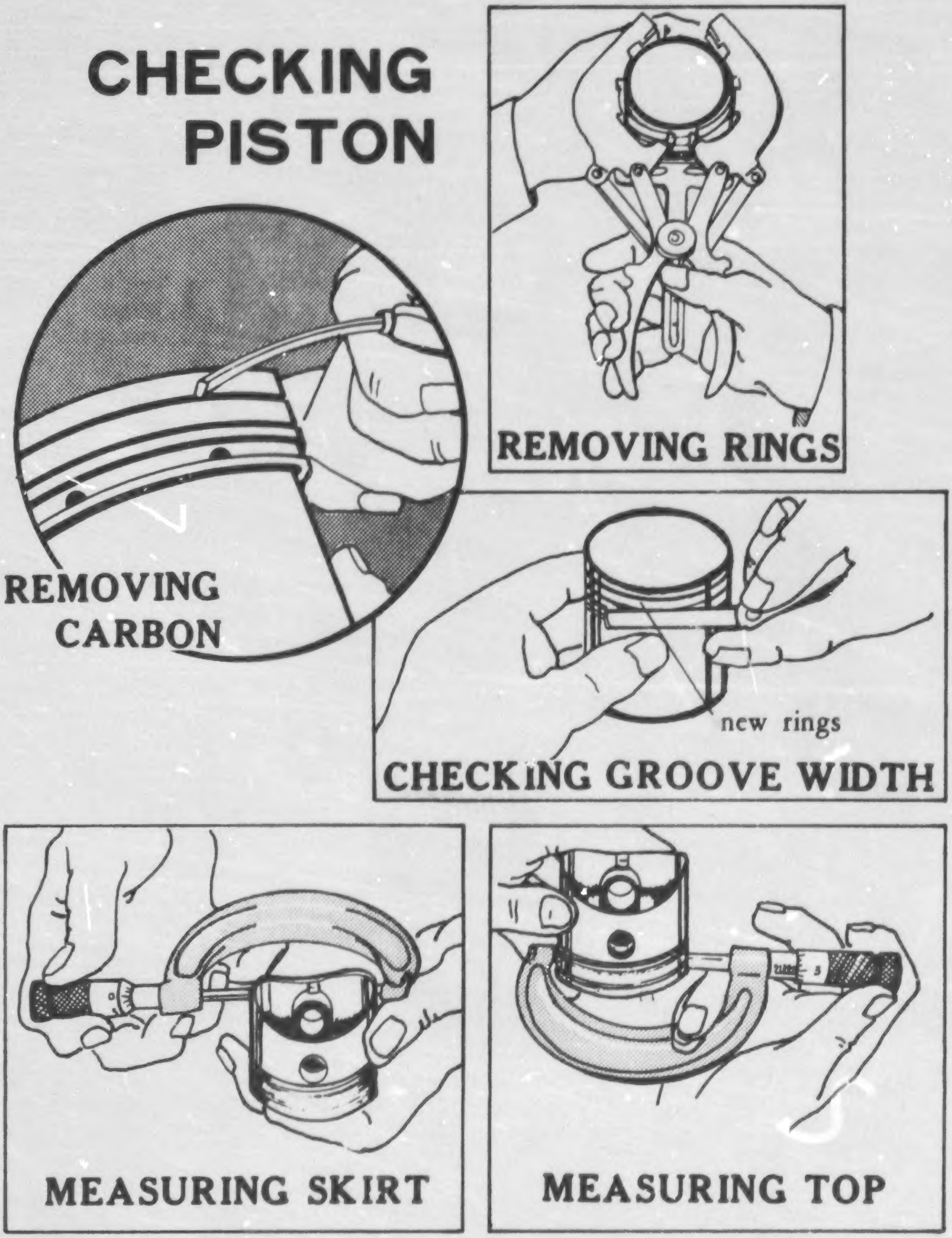

carborundum stone
block

HONING CYLINDER


deglazing brush
sleeve

DEGLAZING PISTON SLEEVE

CHECKING PISTON



REMOVING RINGS

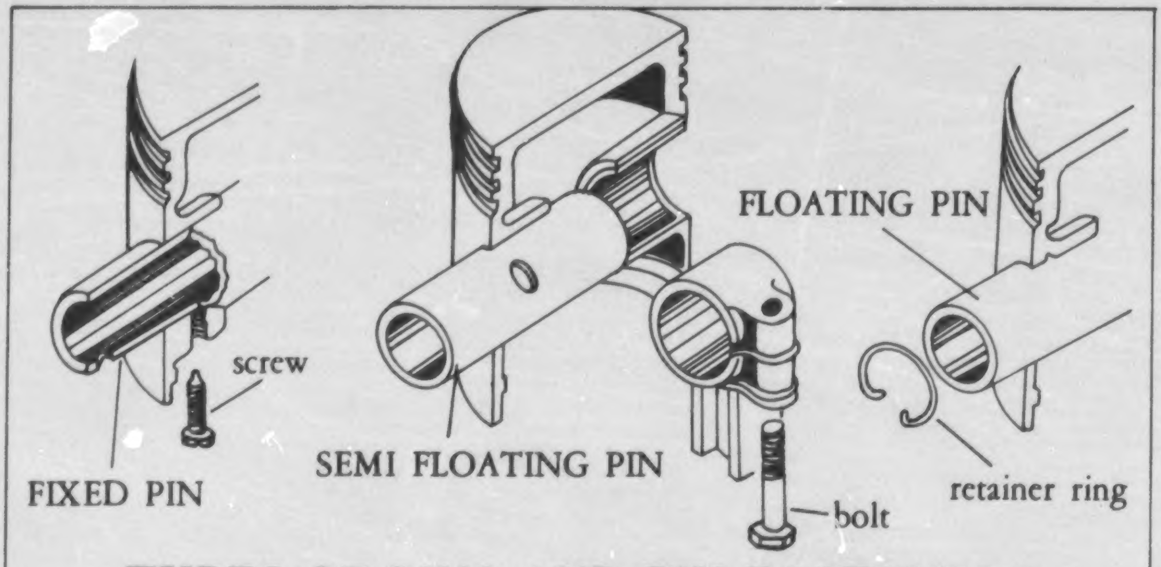
REMOVING CARBON

CHECKING GROOVE WIDTH

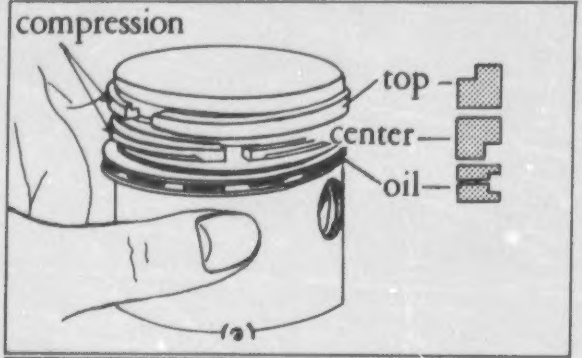
MEASURING SKIRT

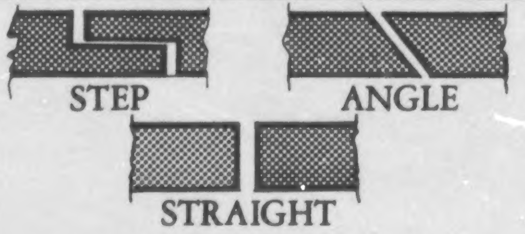
MEASURING TOP

PISTON RINGS AND PINS

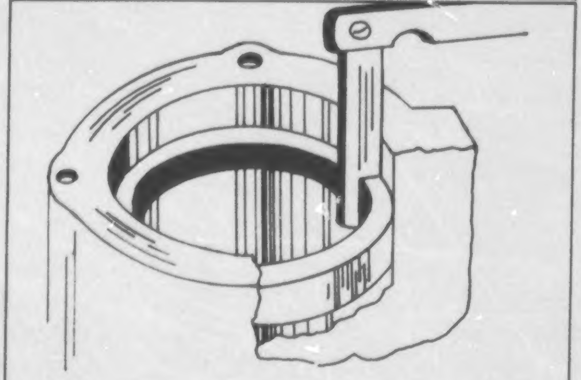

FLOATING PIN
screw
FIXED PIN
SEMI FLOATING PIN
bolt
retainer ring

TYPES OF PINS AND PIN FASTENERS

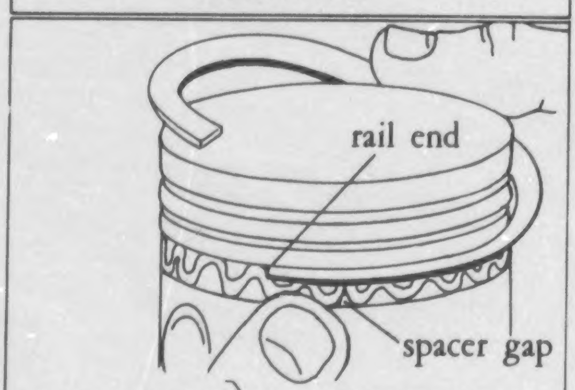

compression
top
center
oil


STEP
ANGLE
STRAIGHT

JOINTS

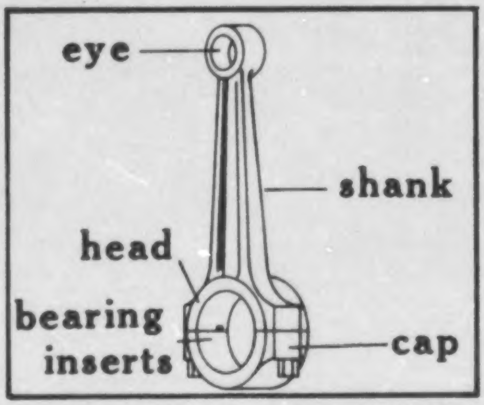


MEASURING NEW RING GAP

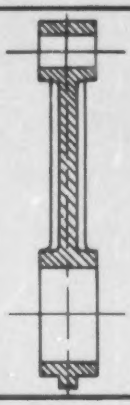

rail end
spacer gap

INSTALLING EXPANDER AND OIL RING

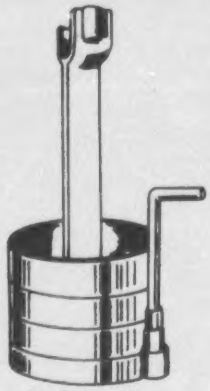
CONNECTING ROD & PISTON INSTALLATION


eye
shank
head
bearing inserts
cap

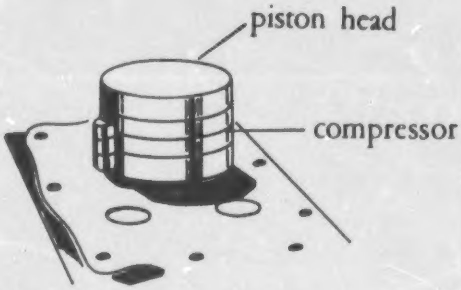
CONNECTING ROD PARTS



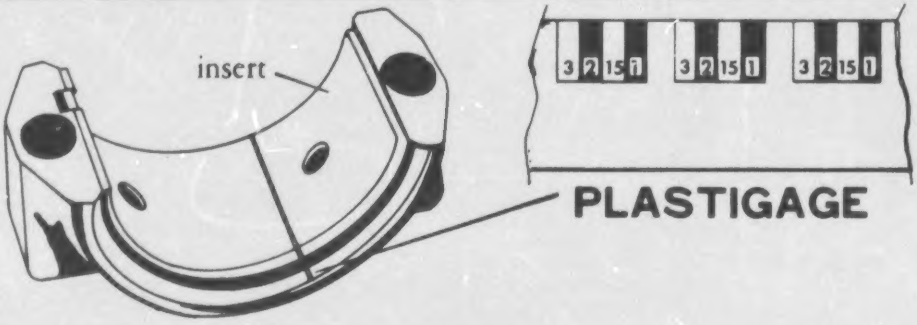
STRAIGHT CONNECTING ROD



PISTON IN RING COMPRESSOR


piston head
compressor

PISTON FORCED INTO CYLINDER


insert
3 2 1.5 1
3 2 1.5 1
3 2 1.5 1
PLASTIGAGE

ROD CAP

GENERAL AGRICULTURAL MECHANICS

Unit J: Servicing and Repairing Small Gasoline Engines

Topic 8: Inspecting and Servicing Engine Lubrication System

Suggested Procedures and Activities: Oil and grease samples in glass containers can be used as teaching aids during the class discussion.

1. Purpose of Lubrication

Lubricating oil functions the same in small engines as in large engines. It reduces both friction and wear in the engine. Naturally, when friction is reduced, wear is reduced. Other important functions of oil are:

a. Oil is a good conductor of heat. It dissipates heat by transferring it to metal parts that are cooled by air and water. As the oil leaves the crankcase it carries heat out.

b. Oil forms a film between the piston rings and cylinder walls, locking power in the engine. If the combustion gases were allowed to "blow-by" the piston into the crankcase, the pressure in the combustion chamber would be reduced, thus reducing the power.

c. Oil washes small particles of metal from engine parts. The metal is filtered out or settles in the crankcase. Oil also picks up dirt particles which are either trapped in a filter or the crankcase.

d. Oil serves as a shock absorber, because it is forced from bearing surfaces slowly. The sudden shock of combustion is cushioned by oil as it is transferred to the bearings on the power stroke. This is another reason oil is used to separate parts.

e. Oil is a protector of steel in another way, as it forms a film to keep air and moisture away from the metal. Metal will oxidize (rust) or even corrode if it is not protected.

Transparency No. 1

2. Lubrication in Two-Cycle and Four-Cycle Engines

a. Oil is mixed with gasoline, forming the fuel-lubricant mixture that is used in the two-cycle engine. As the piston moves downward toward the crankshaft, oil is condensed on the bearing surfaces. This movement pressurizes oil in the crankcase. On the upward movement, oil condenses from the fuel mixture and lubricates the cylinder walls, piston, and rings. The remainder of the oil is burned in the combustion chamber.

b. In a four-cycle engine, the oil is located in the sump, where it is moved by one of four common methods to bearings and other moving parts. These methods are as follows:

   (1) In the pump and dipper method, oil is pumped and sprayed on the dipper. The dipper splashes the oil to parts inside the engine. In this type of lubricating system, the oil may be pumped into a second sump and then splashed to parts of the engine by a dipper mounted on the rod bearing cap.

   (2) Another type is the slinger method, where the oil is picked up by a rotating slinger driven by the cam gear and splashed about to engine parts.

   (3) The dipper and sump method is very common in small engines. A dipper is mounted on the rod cap, and it also splashes oil to various parts of the engine.

   (4) An oil pump forces oil through drilled passageways to the bearings and other parts. The oil is picked up from the oil sump by the pump. Most oil pumps need little servicing. They are located inside the oil sump.

3. Selecting Engine Oil

Whereas two-cycle engines use two-cycle special oil, lubricating oils used in four-cycle engines are the same oils used in automobiles. Oils are selected according to their API (American Petroleum Institute) service classification and the type of oil by SAE grade (Society of Automotive Engineers), which is the viscosity grade or oil thickness.

a. The API Classification for small engine oil is SD (Service Deluxe) which was formerly MS oil. This type of oil protects the engine against wear, corrosion, rust, and deposits. They also protect the engine against high and low temperatures. SC oils are also used in small engines.

b. SAE Classification identifies the grade of oil by a number. The highest number used is the thickest oil. The most common oils used are SAE 10W, SAE 20, and SAE 30. The "W" means that the oil is also recommended for subfreezing temperature. Multigrade oils are also used in small engines. The most common oil for this area is SAE 10W-30. This oil is referred to as an all-season oil.

c. Most oils contain additives. Pour-point depressants, oxidation and bearing inhibitors, foam inhibitors, rust inhibitors, and detergents are the most commonly used additives. Oils containing detergents are recommended for small engines. Detergents help keep the engine clean by preventing the formation of sludge and varnish.

4. Importance of Lubricating the Small Engine at Frequent Intervals

   a. Oil is changed frequently to remove dirt, sludge, and metal particles, because most small engines operate without an oil filter.

   b. The oil in a small engine usually is very hot when the engine is operating, due to it being air-cooled. The oil oxidizes and breaks down more readily than in a water-cooled engine.

   c. Most small engines operate without any type of oil pressure gauge to indicate low pressure.

   d. Small engines are usually operated on or near the ground, and this makes the engine more accessible to dirt and dust.

   e. Lightweight engines usually vibrate more than heavy engines, and this puts more strain on the bearings. They also use a small amount of oil.

   f. Due to most small engines operating at maximum power output, oil is forced out from between bearing surfaces.

   g. Small engines usually operate for short intervals; therefore, they are started often, causing more wear than running properly long periods of time.

Transparency No. 1

5. Checking and Changing the Crankcase Oil in A Four-Cycle Engine

   a. Check the oil level each time the engine is refueled or every two to four hours of operation. A procedure used in checking the oil is as follows:

(1) Remove the filler plug or cap after cleaning dust, dirt, and grease away from the area.

(2) With the engine level, remove the dipstick, if the engine has one, and wipe clean with a rag. Then re-insert dipstick for checking the oil level. Add oil as needed but never above the "full" mark. Oil should be added if the oil ring is below the "add" mark.

(3) Check the oil level on an engine that has no stick by observing the oil level through the filler hole. Some engines may have a marking or slot that will indicate the level when the crankcase is full. Other engines that have no full marks are considered full if the oil level comes to the top of the filler hole.

b. Oil is usually changed in a new engine after about five hours of operation. After this point the oil is changed about every twenty-five hours of operation except when the engine is operated under dusty or abnormal conditions. A procedure for changing the oil is as follows:

(1) Operate the engine until the oil becomes heated. Hot oil will pour more freely, and the contaminants will be dispersed in the oil that is drained out.

(2) Disconnect the spark plug before attempting to remove the drain plug. If an engine has no drain plug, the old oil is removed through the filler neck. It is a common practice to remove dirt and grease from the plug area before removing it.

(3) Allow the engine to drain long enough so that oil from various parts will drain into the crankcase.

(4) Tilt engine if the drain plug is on the side or when draining from the filler neck.

(5) After refilling the crankcase with new oil, replace drain plug and spark plug wire and operate the engine for a few minutes. Stop the engine and check the oil level. Add oil if necessary to the full line.

References:

1. Roth, Alfred C. and Ronald J. Baird, Small Gas Engines - Fundamentals, Service, Troubleshooting, Repairs, The Goodheart-Willcox Company, Inc., South Holland, Illinois, 1975

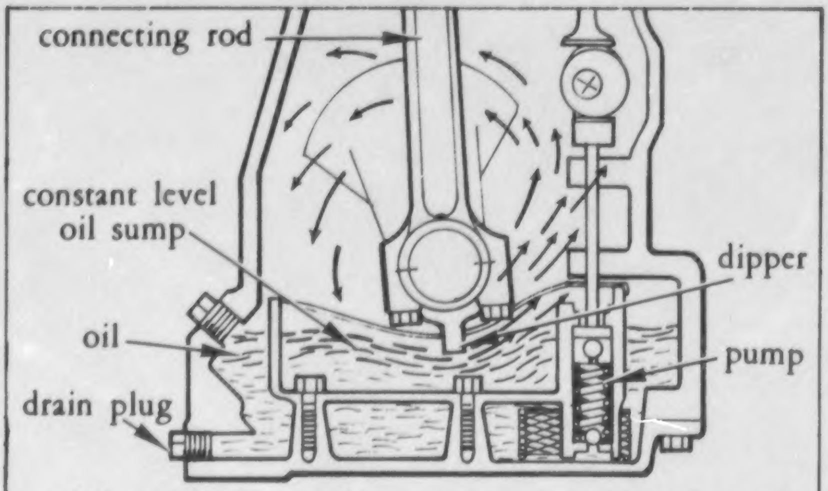
2. Stephenson, George E., Small Gas Engines, Delmar Publishers, Albany,

New York, 1973

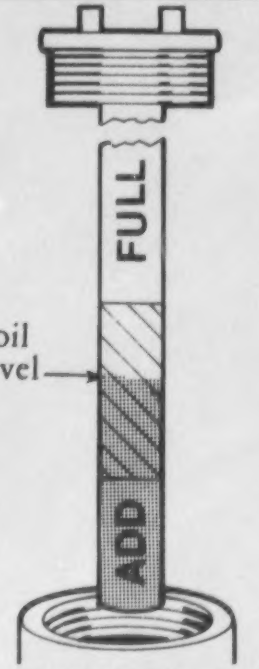
3. "Small Engines, Care and Operation, Volume I", American Association for Vocational Instructional Materials, Athens, Georgia, 1975

4. "Repair Instructions IV", Briggs and Stratton Corporation, Milwaukee, Wisconsin, 1973

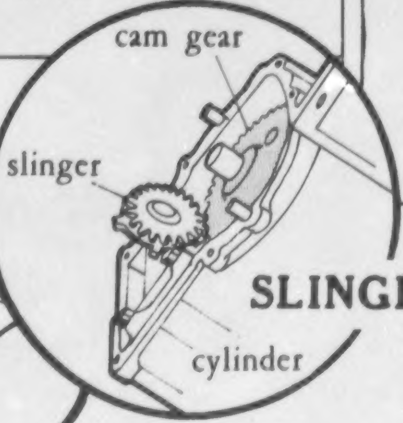
LUBRICATION SYSTEMS


connecting rod
constant level oil sump
dipper
oil
pump
drain plug

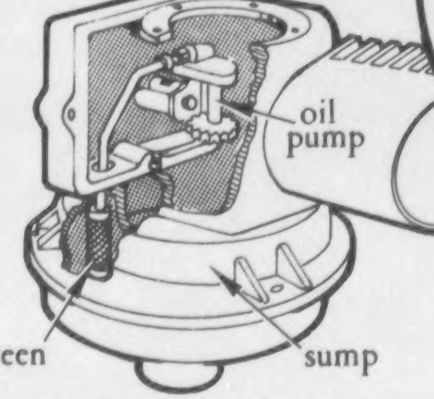
DIPPER-PUMP ENGINE SYSTEM


FULL
oil level
ADD

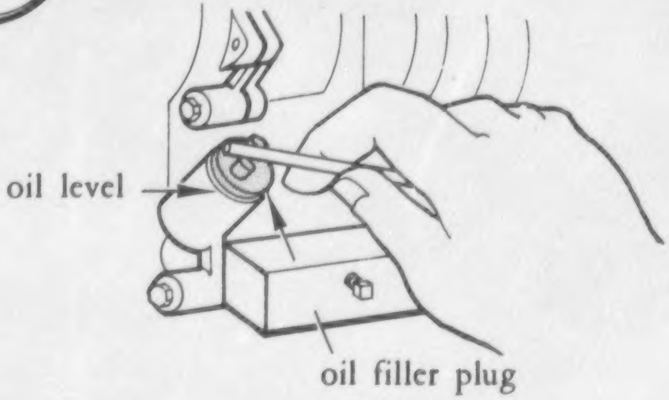
DIPSTICK


cam gear
slinger
cylinder

SLINGER SYSTEM


oil pump
screen
sump

GEAR OIL PUMP


oil level
oil filler plug

GENERAL AGRICULTURAL MECHANICS

Unit K: Setting Up and Maintaining Farm Machinery and Equipment

Topic 1: Use of Service and Operator's Manual

Suggested Procedures and Activities: Review of operator's and service manuals during the class discussion will be helpful. Manuals may be acquired from local farm machinery dealers.

1. Types of Service and Repair Manuals

An equipment manufacturer furnishes an operator's manual for most all types of farm machinery and special equipment. When a farmer purchases a piece of equipment one of these manuals is presented to him by the dealer or sent directly from the factory. If the buyer fails to receive an operator's manual, he should contact the dealer and request one. Following the instructions given in the manual will lengthen the life of the equipment and cause it to function more properly.

There are three important types of manuals used in agricultural machinery service and repair operations. They are the operator's manual, service manual, and special shop service manual. Many service and special service manuals are published by technical publishing companies which are disassociated with the manufacturer of the equipment.

a. Operator's Manual - The operator's manual includes the following information for a single machine or pieces of equipment:

(1) Specifications of the machine or pieces of equipment (name, size, and capacity of parts).

(2) Operation of the machine or equipment (function of parts and starting, handling, and stopping the machine).

(3) Fuels and lubricants used by the machine (type and amount of fuel and lubricants to use).

(4) Servicing the machine or piece of equipment (fuel, cooling, ignition, and lubricants to use).

(5) Trouble-shooting (locating and diagnosing operation problems).

(6) Safety (practices that eliminate accidents).

The performance and length of useful life of a machine and certain types of equipment may depend on how closely the operator follows the instructions in the operator's manual. For example, the manual may suggest how often the valves should be adjusted on power equipment in order that it function properly at all times, or that the chains and belts be adjusted on a combine to make it function properly and eliminate bearing wear.

It is absolutely necessary that the operator follow the instructions of the operator's manual when operating and servicing the machine. Many operator's manuals may be used as references for repair work.

b. Service Manual - This manual is used as a guide when servicing the entire machine. It is used by the service center as a guide for making adjustments and repairs. In general the manual furnishes the following information:

(1) Complete instructions for inspection, disassembly, repair, assembly, and the installation of the parts of a machine.

(2) A description of parts (dimensions and name), tests, and adjustments of certain parts and systems.

(3) Correct name of machine and model.

The service manual is considered a good text book for training service center personnel. The use of this manual may reduce time, error, and cost in making machinery repairs.

c. Special Shop Service Manuals - These manuals are similar to the regular service manual, in that they give information on disassembly, repair, and assembly of machine parts. The specifications include the name, dimension, fits, clearances, and complete instructions on installation of machine parts. Each part is identified similar to the identification system found in a parts catalog for a particular machine. A mechanic may use this type of information when repairing a machine.

The manual gives information on trouble shooting, testing, and lubrication. One of the most valuable features of this manual is the pictures and sketches of parts and systems of a machine. The sketches show the sequence of assembling the parts and systems.

Unlike the operator's manual, the shop service manual may contain a series of certain types of machines. The operator's manual pertains to a single machine.

The shop manual is considered very important for the skilled mechanic. This manual may be considered as an inspection, repair, and adjustment source of information to use in the service center.

2. General Operation Manuals

There are operation and maintenance manuals for powered equipment that give information on operation and maintenance practices but do not refer to any one specific make of machine. The information in this type of material is presented so that it can apply in general to various brand names of machines. This type of manual may deal with belts, chains, bearings, lubricants, gears, paints, and seals. It also may explain the servicing of parts, care of the equipment while in storage, trouble shooting, and an hourly or daily check schedule. Some general operation manuals present information on starting, operating, stopping, hitching, unhitching, and adjustments and controlling the movement of the equipment. For example, a general maintenance manual for planters may give information on the care of major parts, adjustment of the entire planting mechanism, safety practices, lubrication, and other practices to reduce excessive wear. This type of service manual is not used for repair work other than identifying the parts in a general way.

The contents may include:

Information on maintenance after a certain number of hours of operation and information on daily care of the machine.

Information on the following maintenance and care practices:

Servicing parts that use oil and grease

Servicing the electrical system

Servicing the fuel system

Servicing the brakes

Servicing the steering system

Servicing the power train

Servicing the cooling system

Servicing tires and belts

References:

1. "Tractor Operation and Daily Care", American Association for Vocational Instructional Materials, Athens, Georgia, 1970

2. "Tractor Maintenance Principles and Procedures", American Association for Vocational Instructional Materials, Athens, Georgia, 1975

GENERAL AGRICULTURAL MECHANICS

Unit K: Setting Up and Maintaining Farm Machinery and Equipment

Topic 2: Some Common Types of Machines, Equipment, and Major Parts

Suggested Procedures and Activities: One of the more common types of field machines may be used as a teaching aid during the class discussion. It may be necessary to conduct the class in the farm mechanics shop if a machine is used. A disk harrow, grain drill, planter, moldboard plow unit, cultivator, mower, baler, or combine could be used for demonstrations in the laboratory.

1. Disk Plows

Disk plows are used where it is difficult to use a moldboard plow. They have an advantage over a moldboard plow in dry and hard soils. They are also used in gumbo, waxy muck, sticky soils, and on hardpans where the moldboard will not scour well. The disk plow is also preferred for rocky, rooty, and stumpy soils.

a. The three most common types of disk plows are:

(1) Direct-Mounted Plows - These plows are attached to the tractor by one-, two-, or three-point hitch linkages and can be raised or lowered hydraulically. They usually are rear-mounted and have a rear wheel to absorb the side thrust.

(2) Semi-Mounted Disk Plows - These disk plows are attached to the tractor drawbar or by a special drawbar. They are raised by moving a lever at the front of the plow. A long rod which extends to the tractor drawbar is used to steer the rear wheel.

(3) Trailing Disk Plows - These plows have three wheels for support and can be pulled by any make of tractor.

b. Draft created by the disk plow is about the same as the moldboard plow; but since the disk plow is usually much heavier than the moldboard plow; its draft is usually greater. The moldboard plow may be set to operate mainly on suction, whereas the disk plow will penetrate the soil due mainly to its weight.

Transparency No. 1

c. The major parts of the disk plow include:

Disk blade	Wheels
Disk scrapers	Wheels weights
Beams and frames	Depth screw
Bearings	

2. Disk Harrows

Disk harrows are referred to as disk plows and disk tillers. A disk turns the soil in one direction, whereas a disk harrow turns the soil in two directions. The concave edge of a disk harrow disk cuts the soil, and the back edge raises the soil and pushes it to the side as a moldboard. The disks on a disk tiller operate at about a 45-degree angle as they cut and mix the soil and trash.

a. The two kinds of disk harrows are as follows:

(1) Single action harrows may consist of two gangs (a number of disks on one shaft rotating in the same direction).

(2) A double-action disk harrow is made up of two sections, one section trailing behind the other. The double-action harrow is called a tandem disk. Furrows created by the front section are turned back by the back section.

b. Parts of the disk harrow are:

Disk blades	Angling devices
Hitches	Wheels (some harrows)
Leveling devices	Frame
Scrapers	

3. Moldboard Plows

In many agricultural areas the moldboard plow is the most commonly used piece of equipment for seedbed preparation. The plow slices, lifts, and turns the soil. The plow may be one of four types: stubble, general purpose, breaker, or high-speed. Each of these types perform a specific function.

a. The three types of moldboard plow draft are:

(1) Trailing
    Regular -- one to eight bottoms
    Two-way -- one to four bottoms
    Middlebreakers -- one to four bottoms

(2) Mounted
  Regular -- one to five bottoms
  Two-way -- one to two bottoms
  Middlebreaker -- one to four bottoms

(3) Semi-mounted
  Steerable -- over five bottoms
  Non-steerable -- one to five bottoms

b. Plow parts include:

(1) The beam or frame holds the bottoms in the correct position.

(2) The frog is that part of the plow bottom to which all other bottom parts are attached.

(3) The share is that part of the plow bottom that cuts the underside of the furrow slice away from the land.

(4) The moldboard is the part that turns the furrow slice.

(5) The landside is the long flat metal piece which absorbs the side force created when the furrow is turned and levels the plow bottom into a free floating position.

(6) The plow bottom lifts, turns, and pulverizes the soil.

(7) Plow coulters are round flat disk blades used for cutting soil and trash ahead of the plow.

Transparency No. 2a

4. Chisel Plows and Subsoilers

Chisel plows and sub-soilers are different from other plows, tillers, and harrows. Chisels are used to break the hardpan, and sub-soilers are to break up the subsoil. There are several types of chisels that are used as cultivators. The depth of operation on one type is controlled by raising or lowering the frame on a set of wheels. The wheelless type is controlled by a hydraulic lift. Also, some chisels are equipped with reversible shovels, and others are equipped with sweeps to break the soil. Chisel parts are shovels or sweeps, standards, springs, frame, wheels (wheel type) and hitch. There may be several standards mounted on one frame.

A subsoiler usually consists of one to three shanks. It also may be wheeled or hydraulically mounted. The parts are: the point, standard, hitch, mask, frame, and wheels (wheel type). Usually sub-soilers require more draft than any other type of plow per plow point.

Transparency No. 2b

5. Planters and Drills

Row-crop planters and grain drills operate on similar principles. Both planters and drills open furrows for seed, drop seed from a hopper, and cover the seed. There is a difference in the two pieces of equipment; planters will drop seed in check rows or hills, and they are generally used to plant larger seed than drills. Rows are much closer together on a drill than on a row crop planter. Some so-called drills broadcast the seed.

Planters and drills may use disk, shoe, or hoe openers. Planters are usually equipped with rotating plates with notches or holes to receive the seed, whereas drills are either equipped with a fluted wheel feed or a double-run feed to receive the seed.

a. Kinds of planters include:

(1) Front, center, and rear mounted planters - These types of planters may have adjustable weight carrying wheels or they may be carried on beams that are raised and lowered hydraulically.

(2) Trailing Planters - These planters are drawn by a tractor. They are mounted on wheels.

Planters are also classified according to the way they place the seed. For example, a drill planter drops seed in a row at a distance apart according to the adjustment made in the seeding rate mechanism. A hill-dropping planter collects a certain number of seed and drops them at regular intervals in hills. A check-row planter is set to drop seed in squares.

b. The major parts of a planter include:

Hopper
Seed mechanism
Seed tube
Wheels

Driving device
Furrow opener
Covering device
Frame

Most planters are equipped with a clutch to drive the plates. If the planter does not have a clutch, the drill shaft turns continuously.

c. Grain drills may be classified according to the feed mechanism and depth of seeding. Two types of feeding mechanisms are fluted force feed and internal double run. Most drills are dual purpose; that is, they can be used to sow seed shallow or deep. Surface drills sow seed shallow, and deep-furrow drills sow seed deep.

The parts of a drill are:

Hopper
Seeding mechanism
Seed tubes
Furrow openers
Frame
Dragbars
Wheels
Covering devices
Driving devices

Transparency No. 3

6. Cultivating Equipment

Most cultivating equipment performs one or more of the following functions: kills weeds, tills the ground, aerates the soil, and stirs and mulches the soil. Light chisels, rotary hoes, spike tooth harrows, and certain types of light weight disk equipment are used to till the soil at a shallow depth and kill weeds. These field cultivators (cultivators that till and mulch the soil) are usually trailing type equipment which are mounted on wheels. Most of the row crop type of cultivators are either front, rear, front and rear, or central mounted on the tractor.

a. Cultivators are equipped with the following working points: shovels, sweeps, disks, spikes, furrows, and knives. The type of soil, crop, and weed determines the type of point that will be used.

b. The parts of a sweep assembly unit include:

Shank
Tension adjusting screw
Sweep setting screw
Frame
Sweep direction clamp adjustment
Gauge wheels (some units)

Transparency No. 4

7. Sprayers

a. Sprayers are used to apply herbicides, insecticides, fungicides, defoliants, and in some instances fertilizer. They are usually classified as high and low pressure units. For example, the sprayer may operate at over 100 pounds per square inch or as low as 20 pounds per square inch.

The low pressure sprayer is most commonly used for weed and brush control, insect control, and disease control. The parts of a power sprayer are: the tank, agitator, strainers, pump, hoses, boom, nozzles, gauges, regulator valve, air chamber, and cut-off valve. The most important part on any spray unit is the pump. The four types used on sprayers are: rotary, pneumatic, reciprocating, and diaphragm.

b. Power dusters are usually classified according to the type of power used to operate the duster-tractor power takeoff or engine. They also may be divided into outlet types-single outlet units with one hose and one nozzle and multiple outlet units with more than one nozzle.

Power dusters may have these general parts: hopper with agitator and feed regulator, fan distribution system (hose and nozzle), and power source.

If a power sprayer is engine powered it may be mounted on a trailer or hauled by a truck. A unit that is powered by a tractor power takeoff is usually mounted on the tractor.

Transparency No. 5

8. Fertilizer Distributors, Applicators, and Manure Spreaders

a. The two most commonly used dry types of fertilizer distributors are endwheel and trailing endgate which are mounted or pulled by a tractor. Fertilizer distributors are found on many farms. They may be part of a planter hopper unit, grain drill hopper unit, mounted on a cultivator, mounted on the tractor frame, pulled by the tractor, and even mounted on an airplane. Most units are mounted on wheels and pulled by tractors.

The parts of a dry type fertilizer distributor include:

Agitators and rotors
Feed shutters
Levers
Hoppers
Frame
Tube
Wheels and axles
Opener
Blades and brushes

The end wheel type that is pulled behind a tractor may vary from about eight feet to twelve feet wide. This is the width that fertilizer is applied in one swath. Another type that broadcasts the fertilizer material is a trailing endgate distributor. Revolving disks scatter the fertilizer or lime as it is fed from a large hopper.

b. Liquid and gas fertilizer applicators are either mounted on the tractor or mounted on wheels and pulled behind the tractor. Anhydrous ammonia is handled by putting it under pressure in a steel distributor tank. At normal temperature it becomes a colorless alkaline gas. The parts of an applicator are:

Ammonia tank
Outlet valve
Main and knife hoses
Shut-off valve
Manifold
Knife tube
Applicator knife
Regulator

Nonpressure liquid tanks are pulled as separate pieces of equipment and mounted on planters and cultivators. They are used to apply complete neutral solutions (combination of nitrogen, phosphorus, and potash), nitrogen solutions, and potash solutions. Aluminum or stainless steel tanks should be used on nitrogen applicators, and stainless steel or plastic tanks are used on potash applicators.

c. Manure spreaders are usually mounted on one or two sets of wheels and pulled by a tractor. On some spreaders the spreader parts (conveyor and beaters) are operated by the tractor engine through the PTO shaft. If the spreader is not connected to the PTO shaft, the parts are powered by spreader wheels. The boxes of modern spreaders are made of steel. Major spreader parts are:

Upper and lower beaters
Frame
Box
Conveyor or apron
Conveyor drive
Spreading device

Transparency No. 6

9. Mowers and Rotary Cutters

a. Most of the cutter bar type of mowers are mounted on the tractor. These types of mowers are either mounted at the rear of the tractor or just ahead of the rear wheels. Integral rear mounted mowers receive power by V-belt from the power takeoff. The cutter bar is lowered and raised hydraulically. If the cutter bar is mounted on the side (between rear and front wheels) it is either powered by the PTO, V-belt, or hydraulic power from the tractor.

Trailing draw bar type of mowers are mounted on a single set of wheels and pulled behind the tractor. Power for the knife drive is transmitted by a V-belt, chain, or gear from the PTO.

The parts of the cutter bar type of mower include:

(1)
- Cutter bar
- Knife head
- Inner shoe
- Bar
- Guard
- Knife clip
- Pitman
- Outer shoe
- Wear plate

(2)
- Mower assembly
- Inner shoe
- Outer shoe
- Cutter bar
- Frame
- Drive assembly
- Swath board
- Pitman

b. Rotary cutters are used to control weeds and brush in pastures and fields. They are also used to shred stalks of cultivated plants. This type of mower is not used in the same manner as the cutter-bar mower. Instead of mowing the plants so that they lie in a uniform swath, the rotary mower shreds and lacerates the plants.

Rotary cutters are mounted semi-mounted on the tractor. These is also a trailing-type cutter that is mounted on wheels and pulled behind the tractor. The cutter blades are powered by the power takeoff that connects the mower direct drive. The cutting height is either adjusted by hand or by a remote hydraulic cylinder mounted on the mower.

The major parts of a rotary cutter are:

- Frame
- Wheels (trailing)
- Gears and housing
- Blades
- Drive shaft
- Cylinder (hydraulic lift)

Transparency No. 7

10. Hay Harvesting Equipment

a. Hay conditioners are used in hay harvest to crack, crimp, and crush the plant parts, mainly the stems, in order that more surface will be exposed to air and sunlight which hastens moisture evaporation and speeds field curing. The most common types of conditioners are:

(1) The corrugated-roll which crimps, cracks, and bends the hay either

between two steel rollers or one steel and one smooth rubber roller. The rollers have ridges that resemble teeth in gears.

(2) The smooth-roll type conditioner has either two rubber rollers or one rubber and one steel roller. They are made with small grooves that aid in picking up the hay. This type of conditioner crushes the plant.

(3) Flail mowers are hay harvesting machines that are used as a conditioner. The hay is chopped by knives or hammers that are attached to a cylinder.

A hay conditioner may have the following major parts: frame, PTO drive, shield, cross drive wheels, rollers, drive mechanism, rollers, height adjustments, and equipment wheels.

b. The most commonly used hay rakes are the side-delivery, dump, and sweep. The side-delivery rake is the most popular among hay producers. This type of rake lifts the hay and places it in a windrow. The leaves are supposed to be placed inside the fluffy windrow and the stems on the outside. The parallel-bar and cylindrical-reel and finger-wheel side-delivery rakes form about the same type of windrow. These rakes are mounted on one or two sets of wheels. The left mechanism is either operated by hand or by a hydraulic cylinder that is operated from the tractor. Rake reels are powered by PTO and the drive wheels. The PTO drive receives its power directly from the engine, and the drive wheel system receives its power from wheel traction. Rake parts include:

Main frame
Reel
Wheels
Drive mechanism
Reel frame
Strippers and supports
Adjusting levers

c. Most all hay is baled with a pick up or automatic type baler. This baler picks up, feeds, compresses, and ties the hay during a single field operation. Most balers are powered by the tractor PTO. Some heavyduty balers are powered by an engine mounted on the baler. Also, there is another type of baler that is self-propelled. A common type of baler consists of the following major parts:

Hitch
Power shaft
Flywheel
Pickup
Plunger
Main drive gear
Feeder
Auger

11. Combines

a. The combine is a harvester-thresher. It combines several harvesting operations into one. For example, it cuts the plant, separates the seed from the head or pod, cleans straw and chaff from the seed, and conveys the seed into a container or tank.

b. Combines are classified by the width of cut and the way power is supplied. The larger combines are self-propelled, and the smaller types are powered by the power takeoff from the tractor. The least popular is powered by an auxiliary engine. Some self-propelled combines can cut swaths 20 feet wide. The small PTO driven type may cut a swath no more than five feet wide.

Transparency No. 8

c. A combine can harvest most any type of small grain seed - that is, with proper adjustments. It may be necessary to make adjustments in the principal units listed below:

Cutting
Feeding
Threshing
Separating
Cleaning
Grain-handling

d. The major parts of a combine and their functions are:

(1) The reel moves the plant against the cutter bar and sweeps the cut plant onto an auger or platform. It is located above the platform and cutter bar.

(2) The cutter bar functions in the same manner as a cutter bar on a mower; it cuts the stalks or stems.

(3) The feeding unit on most combines consists of a platform auger, feeder canvas, and feeder. The auger delivers the plant to the feeder, and the feeder delivers it to the cylinder.

(4) The cylinder and concaves are considered as the major threshing unit. Grain is separated from head by angle bars located on the cylinder and in the concave. Some combines are equipped with iron-tooth-type cylinders and concaves. Some loose grain is removed from the straw by a beater that pulls the straw from the cylinder and sends it to the straw rack.

(5) The straw rack is considered the separation unit, even though most of the grain is removed and passed through the cylinder grates. Final separation of grain from straw takes place on the straw rack as the straw is tumbled and tossed. Straw is regulated

over the rack by the beater check flap. The grain pan catches the grain from the concave, cylinder beater grate, and straw rack. The straw travels the full length of the straw rack and is discharged from the combine.

(6) The cleaning unit cleans chaff and other material from the grain. The chaffer is an extension of the grain pan. The cleaning fan blows air through the chaffer, chaffer extension, and shoe sieve. Chaff and light straw is blown out of the combine. Grain is allowed to fall through the chaffer and shoe sieve where it is picked up by the auger.

(7) The grain auger moves the grain to the grain elevator. The grain elevator conveyor chain delivers the clean grain to the grain tank. Unthreshed heads move across the chaffer and shoe sieve to the auger from which they are routed in the tailing to the cylinder for re-threshing.

Transparencies Nos. 9a and 9b

12. Cotton Pickers - Strippers

a. A cotton picker removes locks of seed cotton from the open cotton burr. It performs the type of work that is accomplished by hand. Pickers may be classified according to the way they are powered. There are cotton-picking units (one and two row) that are made to mount on tractors. The most modern type unit is self-propelled. The mechanical features of different brand names may be different. The main differences are the number of rows harvested, type of spindles, height of drums, and method of mounting pickers on tractors. The basic units of a picker are: the picking unit, fan delivery system, platform, controls, and the cotton basket. The principal parts of these units and their functions include:

(1) Stalk lifters, spring fingers, and grid bars move cotton stalks into the picking area.

(2) In the picking unit there are hundreds of spindles carried on spindle bars. Spindles rotate at 90 degrees to the direction of travel as they remove seed cotton from the stalk. A typical machine will have twenty spindles on each vertical bar. The bars are mounted on two drums (one on each side of the row). Spindles rotate and entangle and extract seed cotton from the open boll.

(3) Doffers remove the cotton from tapered spindles after they leave the plant. The stationary rubber face doffers drop the seed cotton so that it can be picked up by air from the conveyor. Cotton from straight spindles is removed by stripper bars as the spindle passes the bar. Doffers do not clean the spindles of dirt, plant sap, and other materials; therefore, the picking unit is equipped with moisture carrying tubes that deliver the water to rubber cleaning pads which clean the spindles.

(4) Cotton is conveyed to the carrying baskets by a fan that draws cotton from the drum through conveyor pipes. Dirt and trash are extracted from the cotton through grates by the air blast before it reaches the carrying baskets.

b. Cotton strippers remove cotton bolls from the plant. Plant leaves are either removed by frost or defoliation. Most strippers are made to harvest stormproof cotton. The two most commonly used strippers are: single and double roll and tine-type. Some types of strippers are mounted on the tractor, while others are pulled by a tractor.

(1) The major parts of a roll stripper may include: pick up grates or lifters, rolls or roll and bar, auger conveyor, pressure plates, fingerbeaters, fan, and conveyor chute.

(2) The major parts of a tine-type picker may include the following: pick up and stripping fingers, upper and lower beater conveyors, cleaner screen, auger, and conveyor chute.

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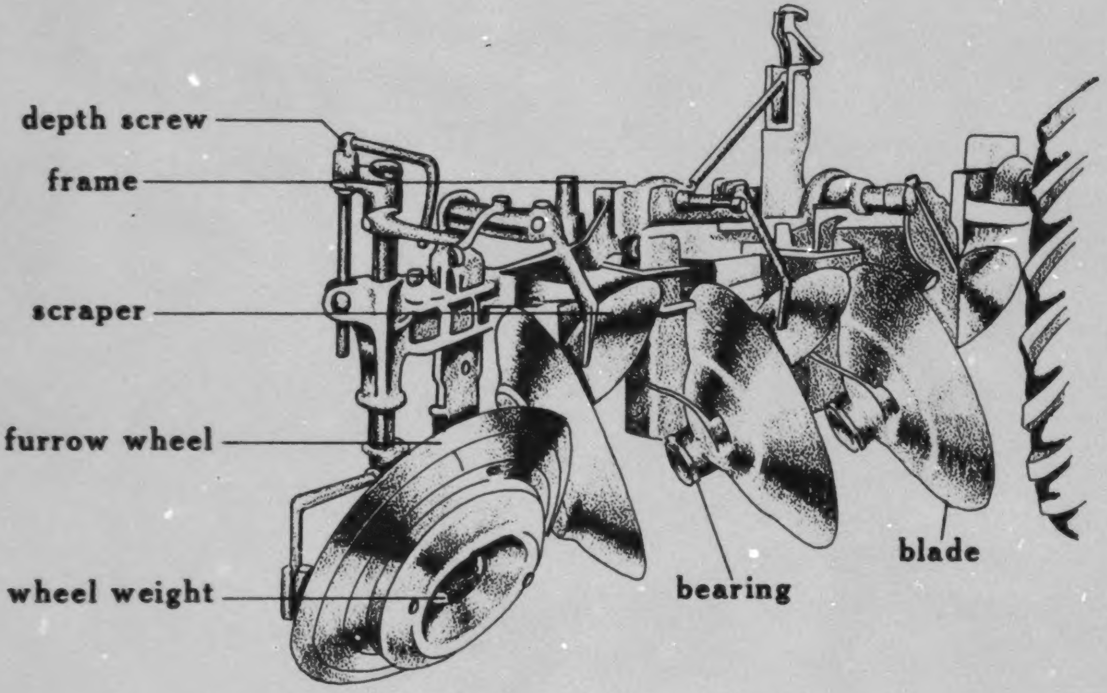
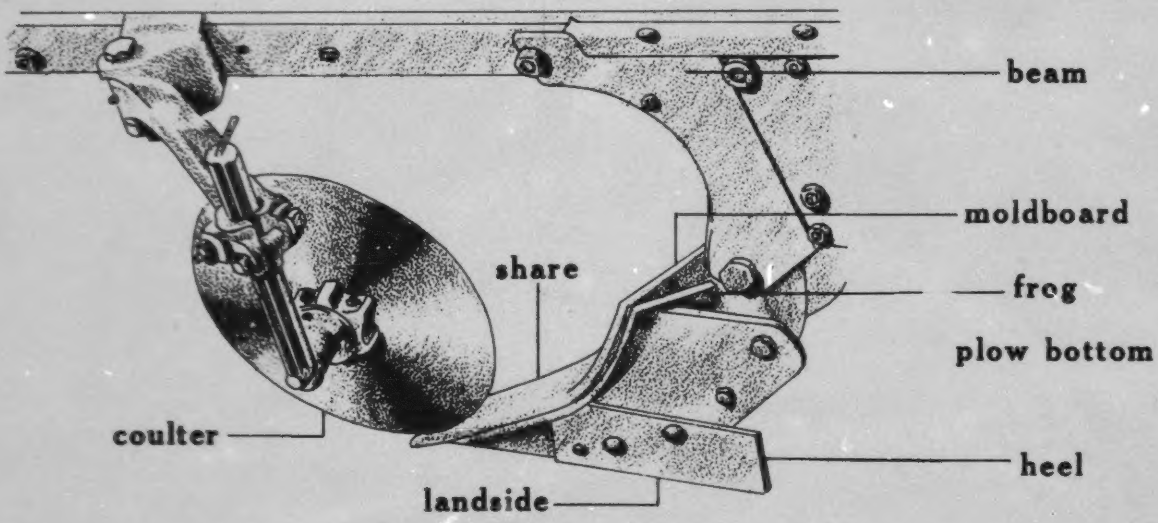
PLOWS

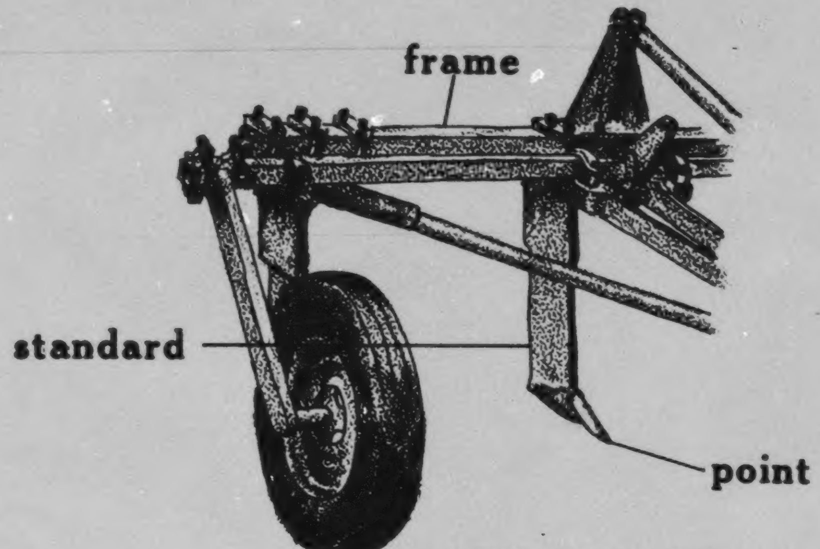

depth screw
frame
scraper
furrow wheel
wheel weight
bearing
blade

SEMI-MOUNTED DISK PLOW


beam
moldboard
frog
plow bottom
share
coulter
heel
landside

MOLDBOARD PLOW

PLOWS & PLANTERS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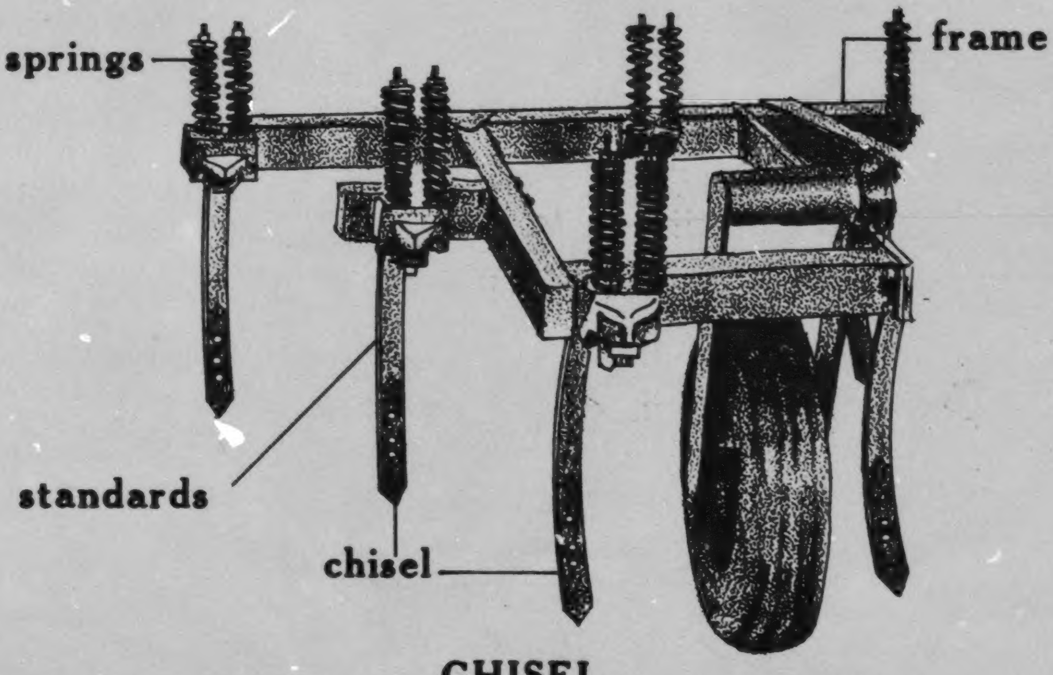
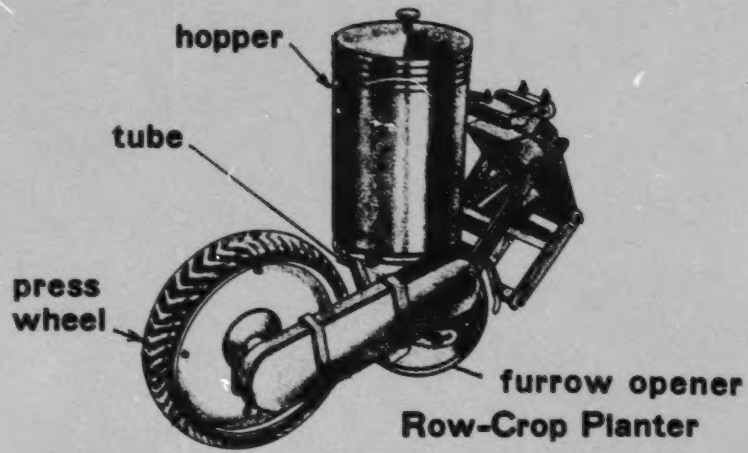
standard
point

SUBSOILER


springs
frame
standards
chisel

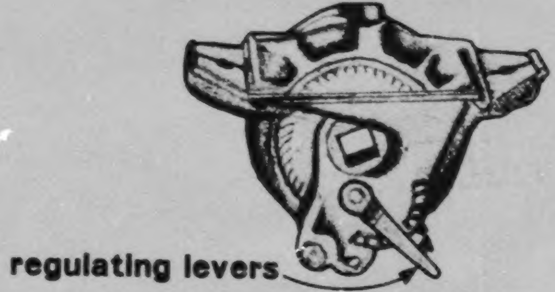
CHISEL

PLANTERS & DRILLS

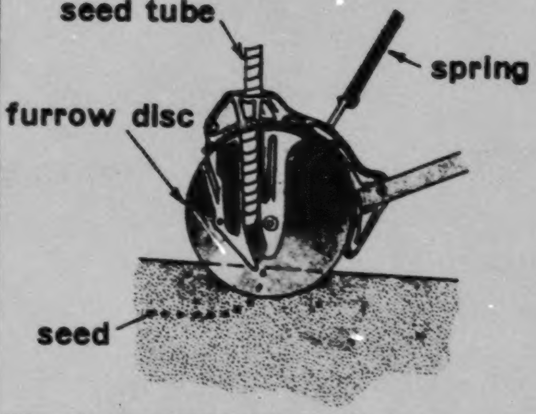

hopper
tube
press wheel
furrow opener

Row-Crop Planter

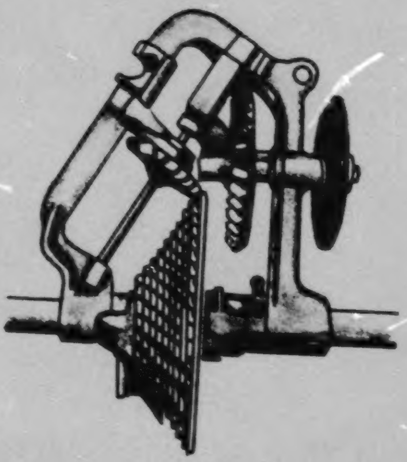
Small-Seed Side Double-Run Feed Cup


regulating levers

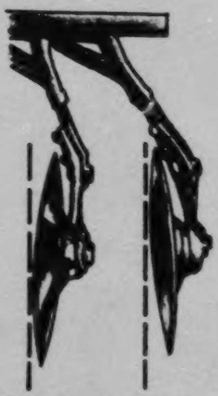
Single- Disc Seed Unit


seed tube
spring
furrow disc
seed

Speed Gears on Drill

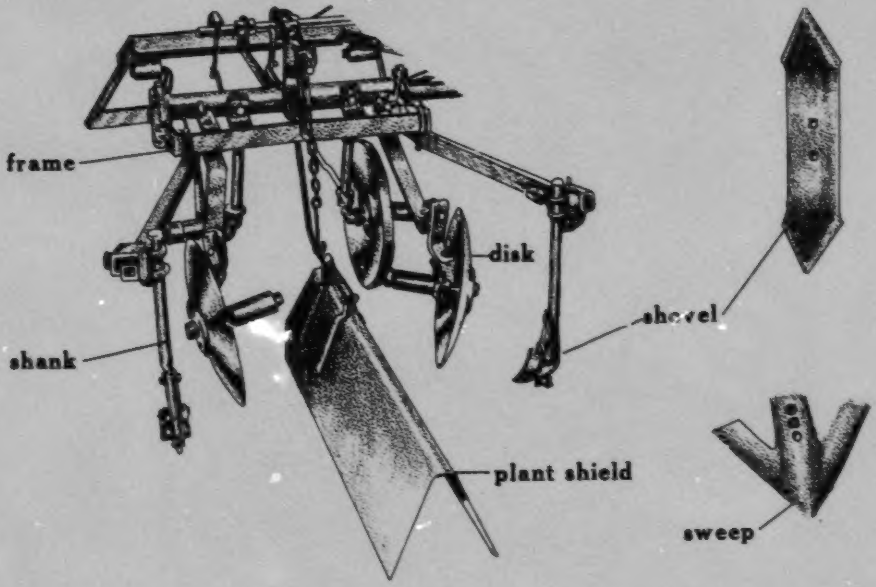


Furrow Opener

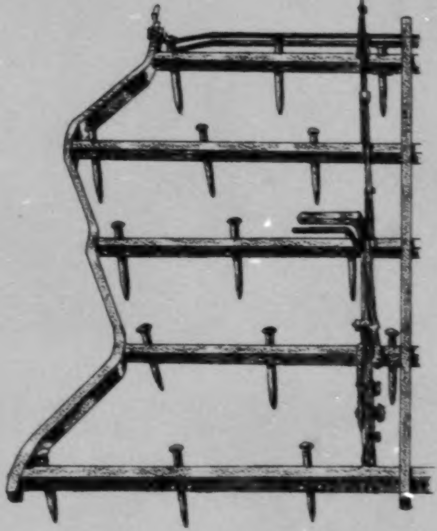


Correct & Incorrect

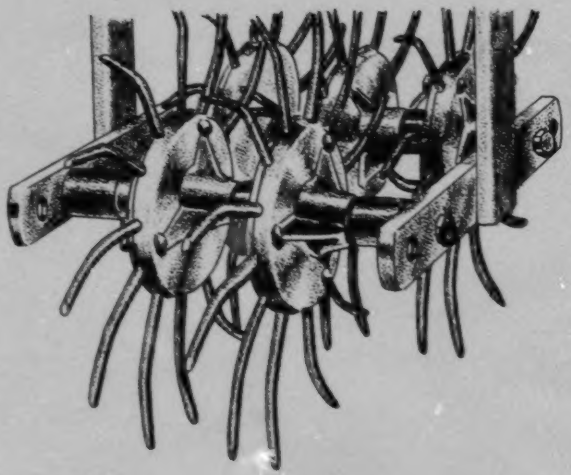
CULTIVATORS


frame
disk
shovel
shank
plant shield
sweep

SECTION OF CULTIVATOR

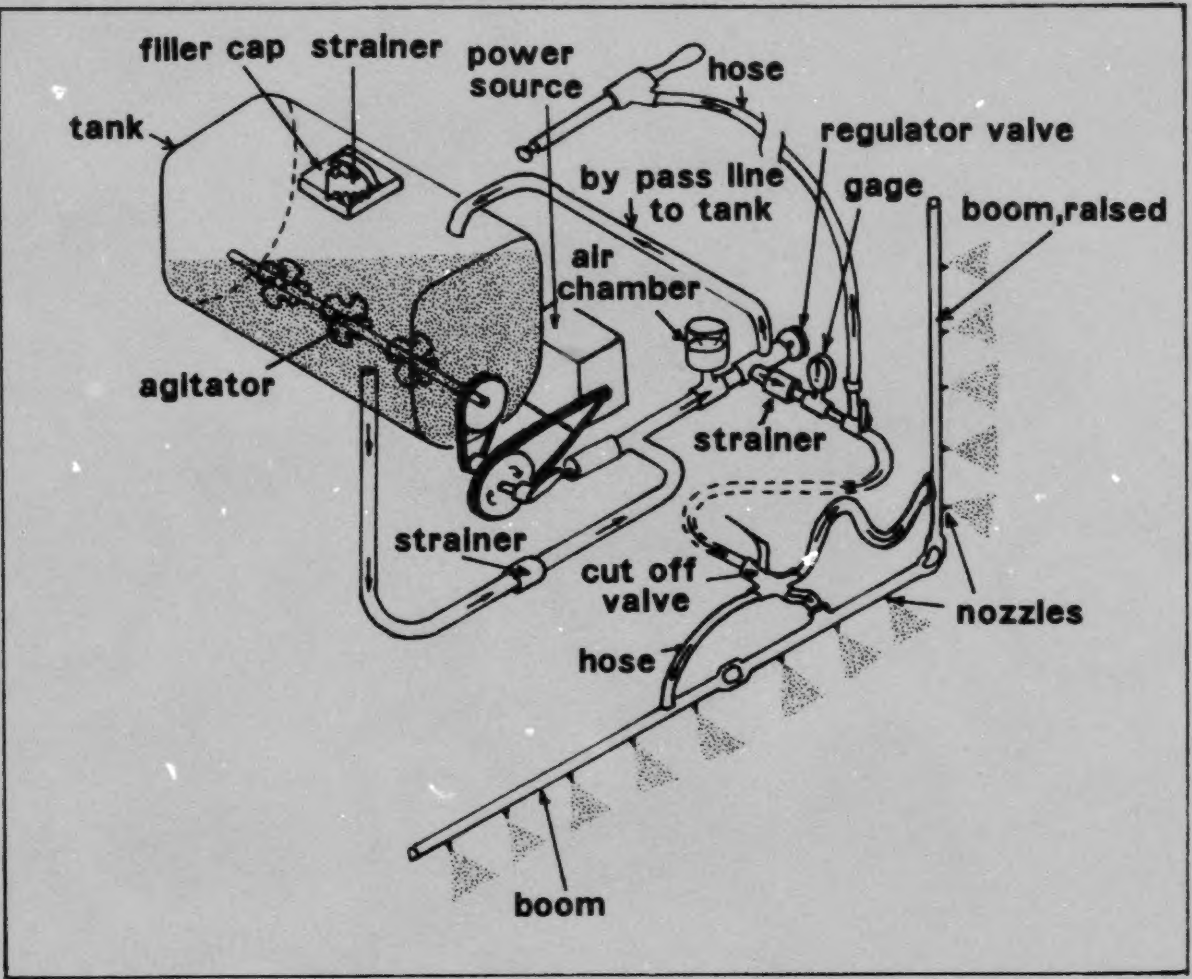


SECTION OF SPIKE TOOTH HARROW



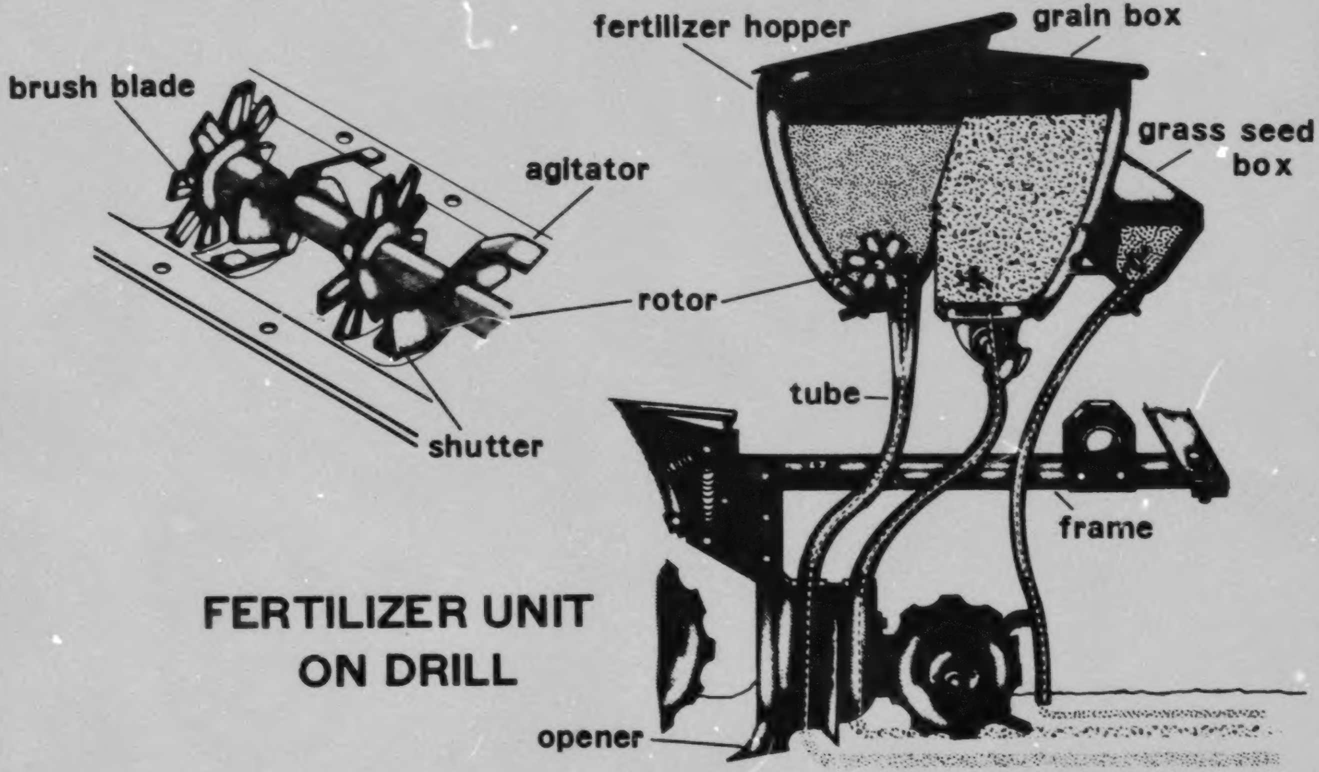
SECTION OF ROTARY-HOE

SPRAYER


filler cap
strainer
power source
hose
tank
regulator valve
by pass line to tank
gage
boom,raised
air chamber
agitator
strainer
strainer
cut off valve
nozzles
hose
boom

Power Sprayer

FERTILIZER DISTRIBUTOR AND APPLICATOR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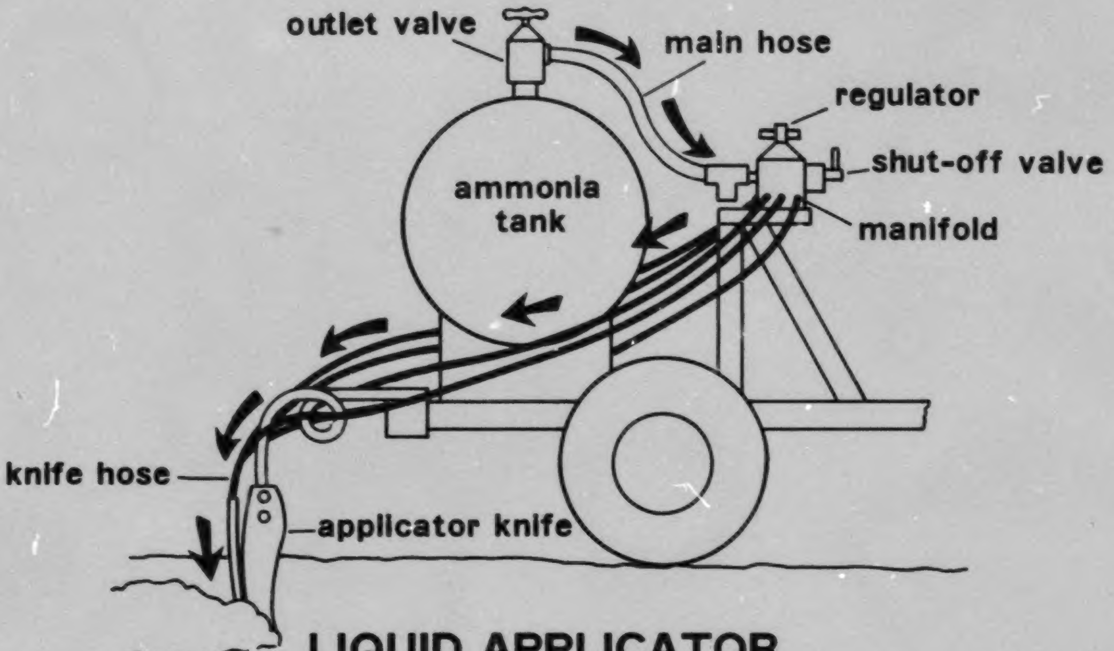
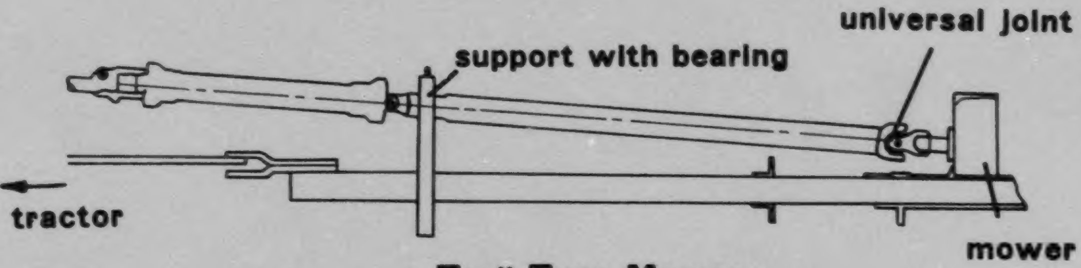
grain box
brush blade
agitator
grass seed box
rotor
tube
shutter
frame
opener

FERTILIZER UNIT ON DRILL


outlet valve
main hose
regulator
shut-off valve
ammonia tank
manifold
knife hose
applicator knife

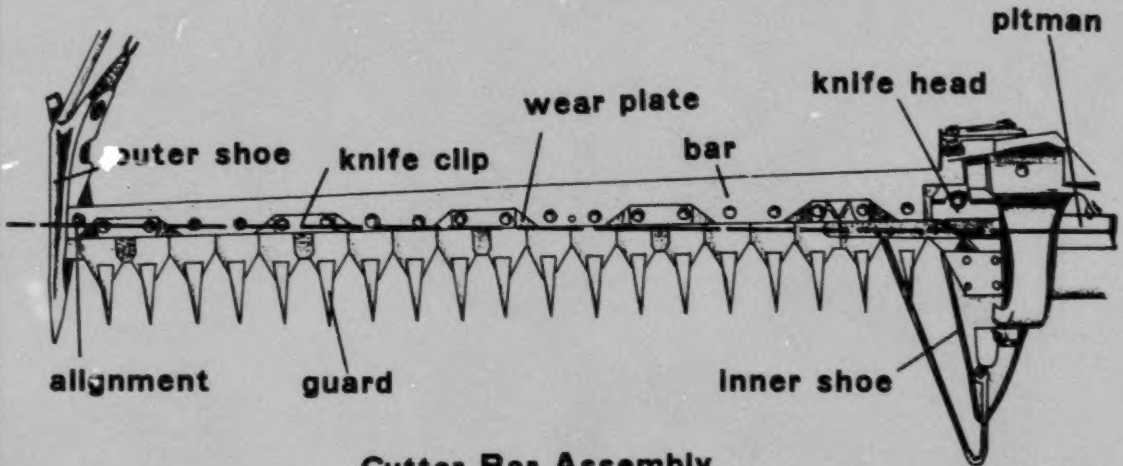
LIQUID APPLICATOR

MOWERS

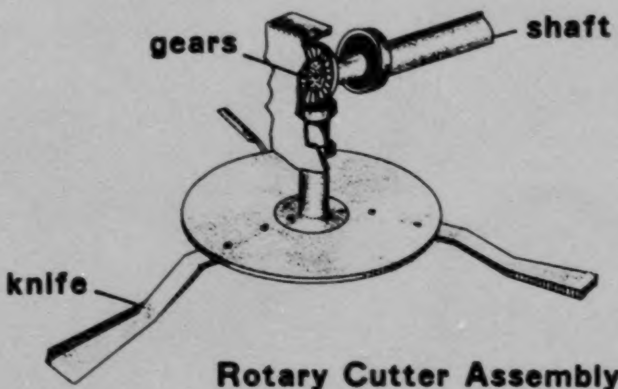

universal joint
support with bearing
tractor
mower

Trail Type Mower

ROTARY CUTTER POWER TAKE-OFF SHAFT UNIT

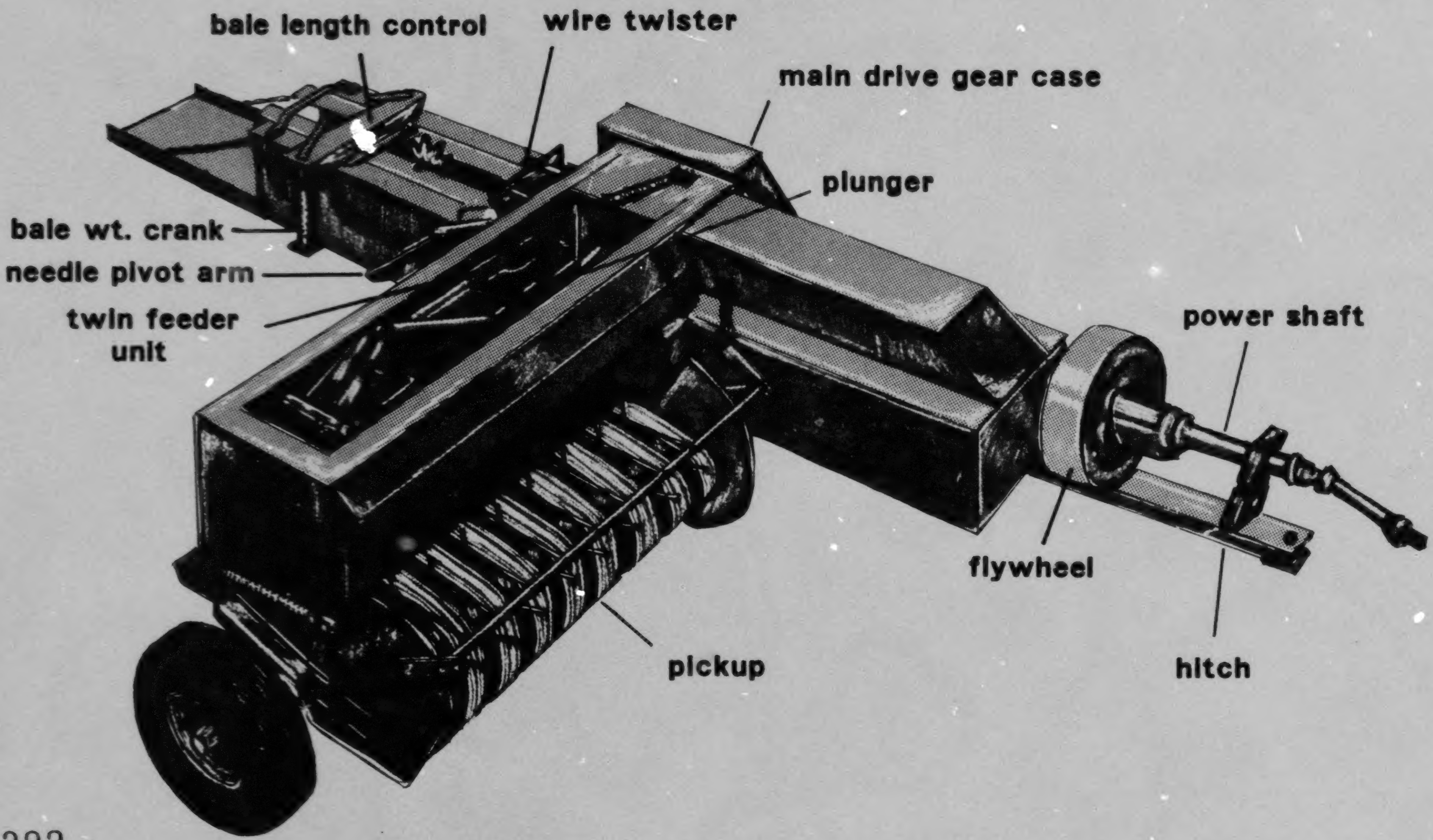

pitman
knife head
wear plate
bar
outer shoe
knife clip
alignment
guard
inner shoe

Cutter Bar Assembly

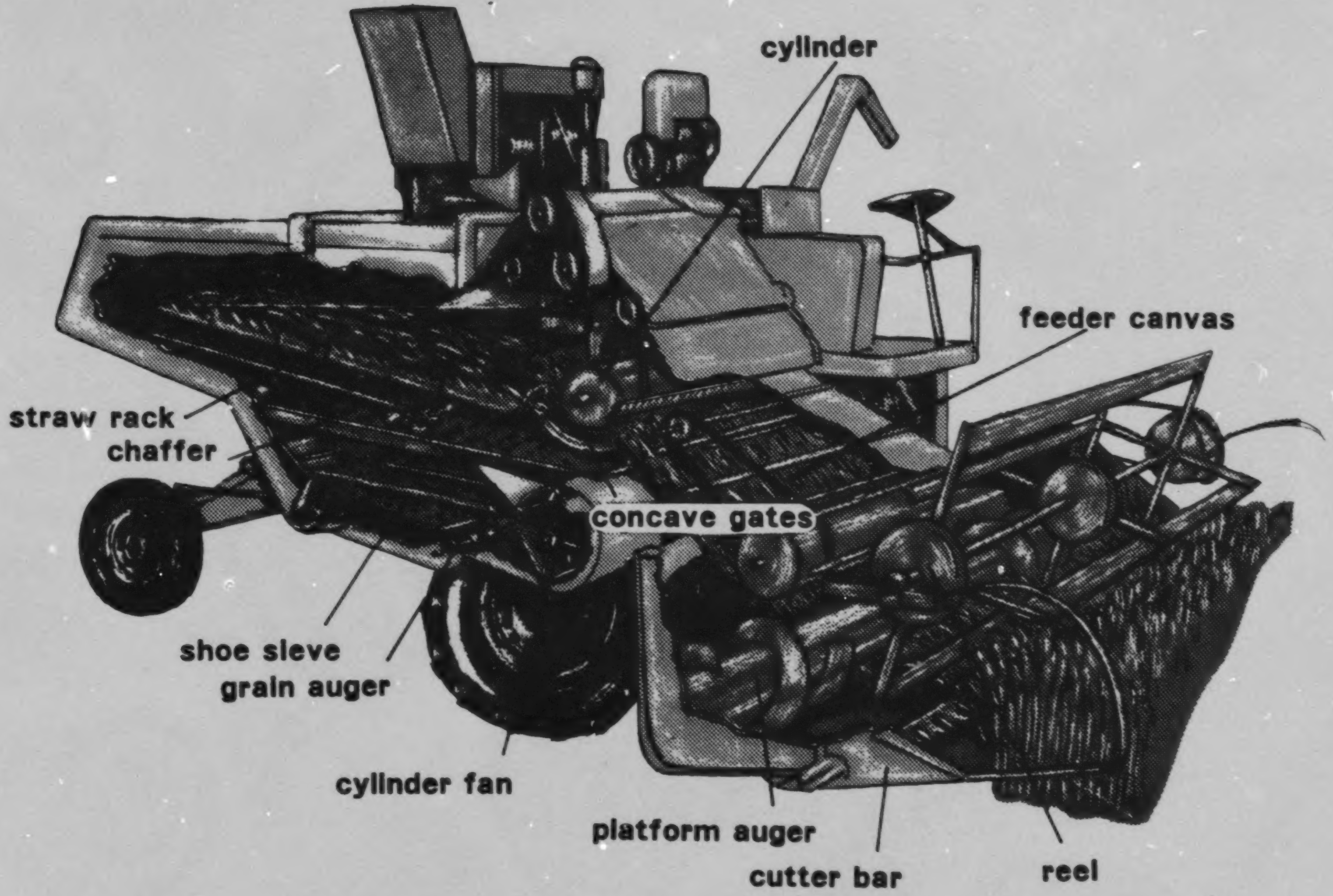

gears
shaft
knife

Rotary Cutter Assembly

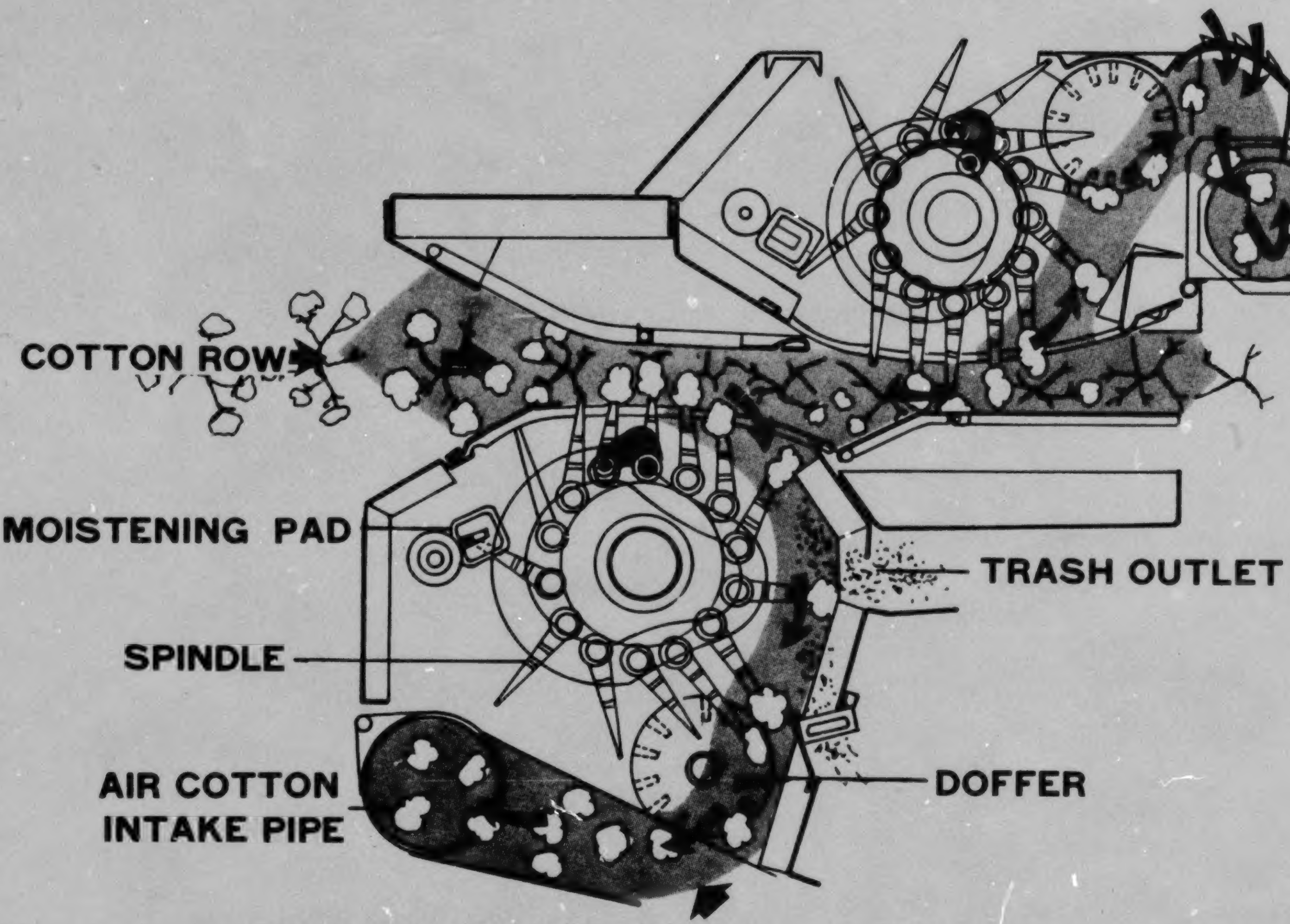
BALER


bale length control
wire twister
main drive gear case
plunger
bale wt. crank
needle pivot arm
twin feeder unit
power shaft
flywheel
pickup
hitch

COMBINE


cylinder
feeder canvas
straw rack
chaffer
concave gates
shoe sieve
grain auger
cylinder fan
platform auger
cutter bar
reel

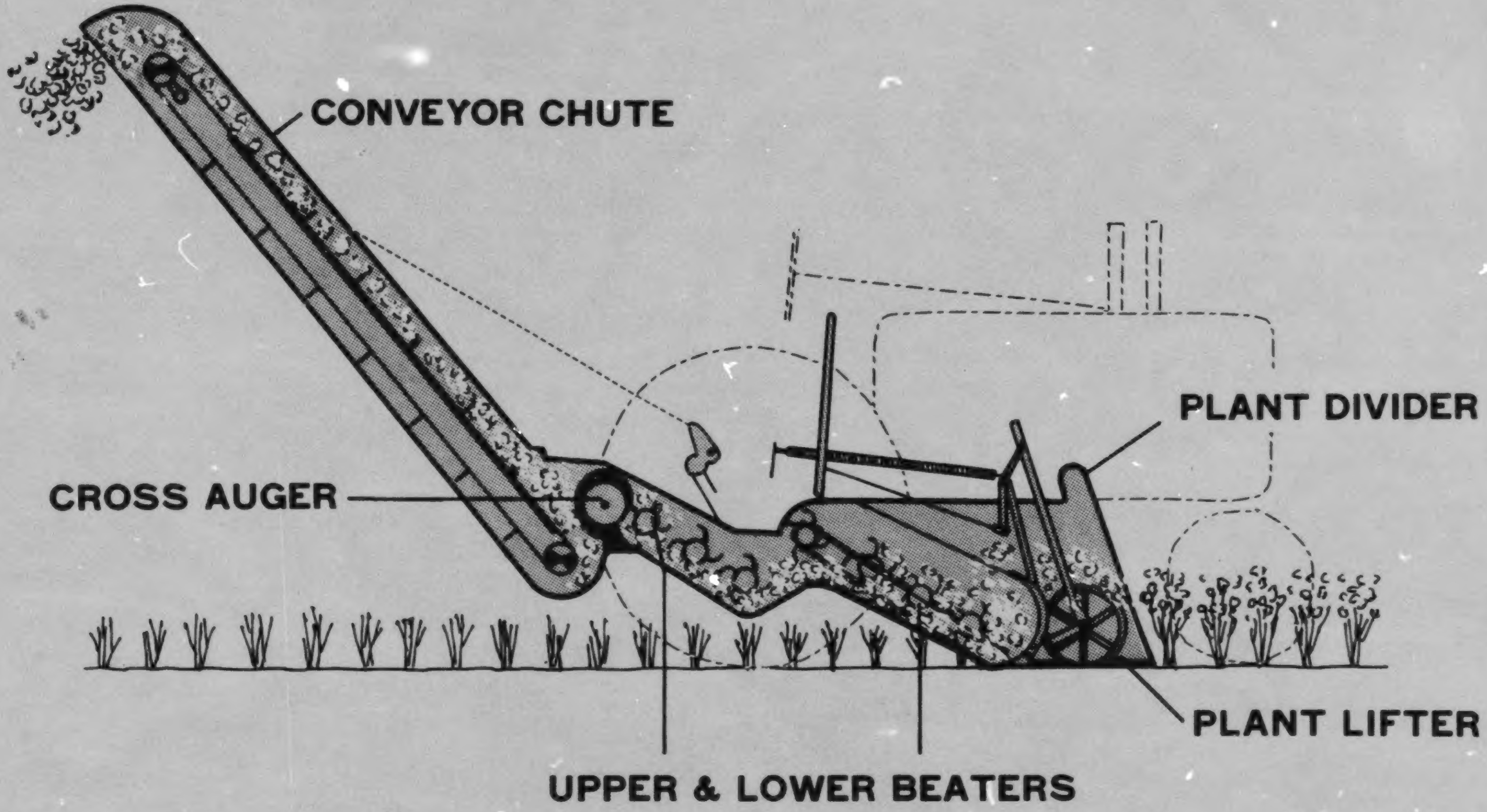
COTTON PICKING UNIT


COTTON ROW
MOISTENING PAD
SPINDLE
AIR COTTON INTAKE PIPE
TRASH OUTLET
DOFFER

396

397

COTTON STRIPPER


CONVEYOR CHUTE
CROSS AUGER
PLANT DIVIDER
PLANT LIFTER
UPPER & LOWER BEATERS

GENERAL AGRICULTURAL MECHANICS

Unit K: Setting Up and Maintaining Farm Machinery and Equipment

Topic 3: Inspecting Machines and Equipment

Suggested Procedures and Activities: After the class discussion move to the shop for a practice session on inspecting a plow, planter, cultivator, or grain drill. Use the inspection form to record the necessary information.

1. Why Inspect Field Machines

All machinery should be inspected periodically during the season or the period that it is used. A machine operator or owner should use a systematic procedure for checking the parts of equipment or machines. Farm machinery may be inspected anytime throughout the year, but the more desirable period for inspection is at the close of the working season. The major reasons for inspecting the machine at the end of the work period are:

a. Adequate time is needed to make a thorough inspection.

b. It may be necessary to replace worn or damaged parts. Also, it may be necessary that the dealer order parts from the manufacturer.

c. The machine should be thoroughly cleaned. This operation should not be a hurried up type of job.

d. Major repairs may require several weeks to complete; therefore, the machine should be inspected immediately at the end of the working season.

2. Procedures Used When Inspecting Machines

Transparency No. 1

a. Some owners and some operators of farm machinery use a special inspection form in order to list all information necessary for making machine repairs. This form contains the following information:

Name of Machine
Make of Machine
Model and Type of Machine
Date of Inspection
Condition of Parts or Assembly
Name of Part or Assembly
Type of Work or Job
Part or Parts Needed
Catalog Number

Inspection forms are usually available from the Agricultural Extension Service and from machinery dealers.

b. Things to check on the more important field machines are:

Disk Plows, Tillers, and Disk Harrows - When making the inspection, check the disk cutting edge for sharpness, bearings for wear, disk cleanliness, looseness, springs for tension, scrapers for adjustment, and frame parts for distortion.

Moldboard Plows - Inspect the plowshare for sharpness and the plow bottom and side for suction. Check furrow wheel bearing, plow beams, braces, hitches, pivots, and linkage for wear and/or distortion.

Chisel Plows and Subsoilers - Look for bent teeth, bent shanks, and bent frame parts on chisel plows and subsoilers. If the plows are on wheels inspect wheel bearings for wear and proper lubrication. Inspect wheel bearings for wear and proper lubrication. Inspect the paint on the frame.

Planters - Inspect the parts of the hopper. All gears, chains, and sprockets should be checked. Inspect cut-off and knockout pawls, bottom rings, and spring tension. Inspect the valve mechanism and furrow openers.

Cultivators - Inspect all parts of the tractor-mounted cultivator for wear. Check shank release (spring, friction, and pin-break) for adjustment. Inspect sweep or shovel cutting edges for sharpness, and check spacing of sweeps or shovels.

Sprayers - Sprayers usually receive better care than other machinery due to their being cleaned after each job. Fertilizer distributors are also cleaned after a job. Sprayers can be easily damaged by chemicals if they are not properly cleaned and inspected immediately after use. The following parts of a sprayer should be checked: nozzles, pressure gauge, belts, pulleys, bearings, hose and pipe connections, agitator, tank, hand gun, valves, strainers, and pump. Check parts that require lubrication.

Fertilizer Distributors, Applicators, and Manure Spreaders - Inspect the hopper for rust areas caused by fertilizer deposits. Check center and wheel bearings for wear and proper lubrication. Inspect the rotor and feed shutters for free movement.

A fertilizer applicator, like many other field machines, must be checked or inspected before and after use. Inspect the valves and hoses for leaks. Check the metering devices to determine if they are functioning under the proper pressure. Inspect wheel bearings for wear and lubrication. After using the applicator inspect the tank to determine whether or not it contains ammonia.

Most manure spreaders are equipped with chain conveyors; therefore, check the chains for proper tension. Inspect all sprockets and bearings for wear. Check beater knives and the spread beater for damage.

Tractor-Mounted Mowers - Check the mower knives for a proper cutting edge. Check for proper knife register in the guards. Inspect the wrist pin, bearing, and flywheel for wear. If the mower is equipped with a pitman check the wear; check pitman lead and lag. Check the bolt for wear in a pitmanless drive mower. There are many other check points on a mower. Some are: the guard alignment, knife straightness, knife head bushing, knife rivets, guard ledger plates, guard lip clearance, adjustable wear, plate, drive pulley on pitmanless mower, and vertical and side play at knife head. Examine the cutter bar assembly for wear.

Rotary Mowers - Check the knives for proper cutting edges, excessive wear, nicks, and straightness. Examine all nuts and bolts for tightness. Check the drive shaft and bearings for wear and adjustment. Check for proper clutch action.

Balers - Balers have many moving parts, and each part serves a very important function for proper machine operation. It is important that the machines be carefully checked throughout the baling season. A frequent inspection should include the following:

Check all belts and chains for correct tension, wear, and alignment.

Check pulleys and sheaves for alignment.

Check bearings and sprocket teeth for wear.

Check the entire feeder unit for wear and damage parts.

Check plunger speed and the plunger and slide blocks.

Check the cutting edge and clearance of the slicing knives.

Check the weight and density of the bales.

Check the entire tying mechanism.

Rakes - Inspect the rake frame, tooth bar, strippers, teeth, and reel ends for damage. Most rake damage is caused by springing or bending certain parts. Check the bearings for wear and proper lubrication. Some rakes are equipped with enclosed drive gears that should be checked often.

Combines - Combines are similar to hay balers, in that they are made up of many moving parts. Some parts may work independently of each other, but if the machine is to operate properly, all parts in each mechanism unit must be in good condition at all times. An inspection of the combine will include the following jobs:

Check for worn and loose chains, sprockets, belts, and bearings.

Check the canvas for tears and check for loose or broken slats.

Check for auger straightness and wear.

Check a spike-tooth cylinder for bent, broken, and worn teeth. Also check the cylinder RPM.

Check for loose rivets and bolts on the straw rack.

Check for holes in the grain pan, dents in the sieves, and bent air fan valves.

Check the elevator and augers for damage.

Cotton Pickers - Cotton harvesting equipment has many moving parts, and some of the basic parts require continuous checking. Some of the inspection jobs are:

Check the spring fingers and stalk lifters for damage. Also check the position of the grid bars on certain types of pickers. Spindles may strike bent bars.

Check spindles (tip barbs) for wear. Cotton picking efficiency depends largely upon the spindle.

Check the picker bars by trying to force them up and down and in and out. Examine all needle and sealed gears on spindle drive shaft.

Check the drum drive shaft gears for wear. Also check the drum bearings.

Check the doffer shaft for straightness. Inspect the O-ring for wear and check for lubrication. Inspect all spline and sprocket teeth for damage or wear. Also check all drive chains.

Check the moistening system for possible water stoppage. Check the hoses for splits, kinks, and corrosion. Check the distributor head for corrosion. Inspect water holes in moistening pads. Also check water lines for leaks.

Check the fan rotor for cracks in blade welds. Check the fan bearings and seals for wear. Check fan for dents.

Check all gears, bearings, chains, pulleys, and sprockets for wear.

Cotton Strippers - The first cotton strippers were very simple pieces of farm equipment. They appeared in the form of a sled with either fingers or rolls that removed all bolls from cotton stalks. This type of stripper required simple maintenance. Modern strippers require about the same maintenance practices that are used on cotton pickers. Strippers inspection jobs are:

Check the plant dividers for dents and bends.

Check the pickup fingers and limb lifters for breaks and bends.

Check the stripper rolls on the roll type for straightness, corrosion, and dents.

Check the conveyor beater fingers for straightness and inspect the finger drums for cracked or bent parts.

Check the auger or augers for straightness and dented blades.

Check all bearings, sprockets, gears, chains, and belts for excessive wear. Check the tension of belts and chains.

3. General Inspection Procedure Used on all Machines and Equipment

If the machine is equipped with tires, they should be checked for wear and general condition. Machine parts that require oil or grease should be checked for proper lubrication. Machines are painted in order to protect the material against heat, moisture, and chemical reaction and to improve appearance. When inspecting the machine at the end of the working season, the paint should be inspected to determine if it is cracking, checking, peeling, and/or chalking.

4. Inspection Periods

There are actually three inspection periods for field machinery, assuming that the machine or equipment is already assembled. The inspection periods are:

Attachment or Prefield - All machines are prefield inspected at the time the machine is hitched or mounted on the tractor. Inspection may include only the hook-up connections or it could include checking lubrication, loose parts, distortion on certain parts, and machine alignment.

Field - Usually field inspection includes the proper function of the machine and its parts. This inspection period is used to make operational adjustments. The second check for alignment is performed at this time. Other things that are checked are: the rate of seeding, correct plow setting and depth of operation, the weight and density of bales of hay, the function of the spray nozzles or nozzle, and the loss of grain when combining.

End of Operation - The end of operation inspection period is used mainly to inspect parts for repair or replacement. This period is also used to check parts for major adjustment. In general, it is the period to inspect the machine for reconditioning. The life of the machine may be prolonged if a thorough end of season inspection is carried out for reconditioning.

End of operation inspection should involve field inspection; the machine must be in operation in order to determine its operating condition. Such conditions as worn bearings, machine vibration, uneven drag, seed distribution, sprayer pressure, and loss of grain from a combine are more easily detected if the machine is in operation.

A record should be made of any malfunction, explaining the condition in detail before the machine leaves the field for the season. This machine record should be used when reconditioning the machine.

References:

1. Phipps, Lloyd J., Mechanics in Agriculture, The Interstate Printers and Publishers, Danville, Illinois, 1967

2. Stone, Archie A., and Harold E. Gulvin, Machines for Power Farming, John Wiley and Sons, Inc., New York, New York, 1967

INSPECTION

MACHINERY INSPECTION FORM

Machine ____________ Date ____________

Make ____________ Model ____________

Name of Part	Condition of Part	Type of Job	Part Needed	Part Number

Detail Information

GENERAL AGRICULTURAL MECHANICS

Unit K: Setting Up and Maintaining Farm Machinery and Equipment

Topic 4: Preparing Machinery and Equipment for Storage

Suggested Procedures and Activities: The use of worn parts such as bolts, chains, bearings, disks, plowshares, mower knives and blades, sprockets, and gears may be helpful as teaching aids during the class discussion.

1. General Practices Used to Prepare Machinery and Equipment for Storage

Some major practices involved in preparing machinery for storage are:

a. Protective Cover - The protective cover for farm equipment, whether it be a tarpaulin or special shed, may be considered special preparation for a piece of equipment in that the paint, metal, and non-metal parts are protected from weather conditions.

b. Marking Parts - All major parts may be identified by making marks on each part when disassembling the machine or piece of equipment. If small parts cannot be reattached to the major parts, they should be placed in containers to facilitate assembly. Heavy plastic bags may be used for this purpose.

c. Cleaning - Even though cleaning of machinery is considered a pre-inspection practice, it may also be recognized as a major pre-storage practice. Harvest and spraying machines are cleaned frequently, due to the nature of work they do and the parts that require maintenance. Cleaning may be done with a cleaning solution, water, air, and solvents.

d. Lubrication - Proper lubrication keeps the machine restored to the desired operating condition. All machines require some type of lubrication. The operator's manual is the best guide to follow when lubricating a machine. Many moving parts on equipment can be lubricated with a pressure gun and grease. If oils and grease do not contain corrosion and rust inhibitors, this should be added when storing machines for several months.

e. Tightening Loose Parts - Most machines consist of parts joined or held together by bolts, cotter keys, set screws, and other locking devices. Bolts, nuts, screws, and cotter keys may be loose, broken, or lost during the time the machine is in operation. Bolts and nuts that do not come off when using ordinary methods may be heated with a gas torch or saturated with penetrating oil.

f. Painting - If a machine is properly reconditioned, all parts subject to rust will be covered with paint or a rust preventive. A machine is easier cleaned for storage if it carries a good coat of high quality paint. Paint helps protect the metal against chemicals that cause corrosion and rust.

The machine inspection sheet and the operator's service manual should be referred to before undertaking a pre-storage reconditioning job.

2. Reconditioning Disk Plows, Tillers, and Disk Harrows

Disk Plows - The following steps may be used to recondition disk plows:

a. Replace lost or broken parts of the machine with new or good used parts. Certain broken parts may be welded. Straighten bent and twisted parts. It may be necessary to remove bent frame parts in order to make the repair. Also, it may be more economical to weld or braze certain broken or damaged plow parts than replacing them with new parts. Some bent or twisted parts can be straightened with a heavy hammer without heat.

b. Replace bearings that are worn too much for proper adjustment. Replace bushings in the roller type disk if they are worn and cannot be tightened snug. Replace worn ball-and-socket gang joints.

c. Follow the recommendations in the operator's manual when sharpening the disks. Most disks are sharpened by either grinding the vertical edge (inside) or turning the edge on the convex side by a special machine.

d. Replace any broken, bent, or weak springs found on the disk plow. Most modern disk plows are free of springs, except near the depth wheel or wheels on some models.

e. A worn or damaged ratchet lift should be replaced or repaired. A damaged or leaking hydraulic lift unit should be repaired. If the ratchet lift threads become damaged, it may be advisable to replace the lift.

Any part of the disk that is disassembled should be reassembled in the reverse order. After the machine is reassembled, test all nuts and bolts for tightness.

3. Reconditioning Moldboard Plows

a. Remove plowshare and sharpen by grinding the share point on the top side. If welding equipment is available, the share edges can be made to last longer by hard surfacing.

b. If the plow is equipped with a coulter, it should be disassembled and sharpened by grinding both sides of the disk.

c. Wheel and coulter bearings that are worn or have damaged caps and shells should be replaced. If the axle is worn, it may be replaced or reconditioned with a weld and ground to the proper size.

d. Straighten or replace parts of the plow frame that are sprung or bent. Most damaged plow beams are replaced due to the lack of proper equipment to straighten the beams. Integral-mounted plows (tractor mounted or tractor carried) have one beam for several bottoms. If any part of the frame or steering mechanism becomes bent or sprung, it should be replaced.

e. Replace badly worn landsides, moldboards, and plowshares. Broken landsides and moldboards may be welded and the welded area ground smooth.

f. Repair the power lift mechanism (hydraulic unit) if leaks appear on the cylinder or hose. Replace parts of the unit that cannot be repaired.

4. Reconditioning Chisel Plows and Subsoilers

a. If the shanks are equipped with springs to let it ride over obstructions, remove and replace weak or broken springs.

b. Remove twisted or bent shanks and either replace them with new ones or straighten shanks by using heat and a blacksmith's or sledge hammer and anvil. The heated area should be tempered.

c. Remove dull, bent, and/or twisted shovels from the shanks. Straighten the bent and/or twisted shovels by using heat and hammering into shape on an anvil. Sharpen dull points on an emery wheel or heat the points and pull them out by using a hammer and anvil. Heated points can be tempered properly by reheating and placing in water after they are shaped.

d. Replace or weld broken frame parts. Tighten all loose fasteners on the frame. Straighten bent frame parts. This job may be accomplished by using a sledge hammer and anvil. If possible bent frame parts should be removed for straightening.

e. Lubricate moving parts and unpainted areas that are exposed to the soil.

5. Reconditioning Planters and Seed Drills

a. Remove runners and disk if they appear dull. These parts may be sharpened by grinding.

b. A bent or twisted frame may cause the runners to be at a different distance from the ground. Straighten the bent or twisted metal with a hammer.

c. Replace weak or broken springs. Replace worn bearings and bushings. Replace worn sprockets and chains.

d. If the valves appear sluggish or worn, replace them. If new hinge pins are needed, drill larger holes for the new larger size pins. Worn valve rods should be replaced.

e. Consult the operator's manual for timing the seed plate driving mechanism. Some planters have timing marks that can be used to set the timing.

f. Usually it is not necessary to replace the drill shaft and clutch, but if a clutch dog is badly worn it may be necessary to replace the part.

The grain drill is repaired in about the same manner as repairing the rowcrop planter, except for the hopper mechanism.

g. Replace weak or broken springs. Compression springs that hold the drag-bar and furrow opener in the ground may lose tension due to frequent adjustment and use.

h. Remove the disks and sharpen them if they seem dull. Damaged furrow openers should be replaced. Damaged or worn furrow opener parts should be replaced. Replace damaged seed tubes.

i. Replace bearings that are worn or damaged. Also, replace chains and sprockets that fail to function properly due to wear or damage.

j. Worn or damaged parts of the feed mechanism must be replaced if the drill is to sow seed properly.

k. If the frame is bent or the hopper dented, these parts should be repaired. It may be necessary to straighten the frame and weld angle iron over the damaged area.

6. Reconditioning Cultivators

a. Repair or replace frame parts that are sprung, twisted, or broken. Broken frame parts can usually be repaired by welding.

b. Sharpen dull shovels, sweeps, disks, and cultivator teeth. If the points of shovels, sweeps, and teeth are not worn beyond repair, they may be reshaped by heating and drawing the point out and then grinding it.

c. Weak and broken springs should be replaced if the cultivator is to function properly. Some cultivators are equipped with trip and compression springs.

d. On cultivators that are equipped with wheels, replace the wheel bearings and wear sleeves that are damaged. It is necessary to install new bearing seals when removing the wheels. On some models of rotary hoses, the bearing resembles a section of pipe with a mounted grease jet. The bearing should be replaced if it becomes worn. It may also be necessary to replace or build up the shaft.

e. Repair crop shields by removing the dents and bends in the metal. Replace the pair of shields if they cannot be repaired so that they will travel evenly in the row.

7. Reconditioning Sprayers

a. Disassemble the sprayer and unclog nozzles with a wood probe. Replace those nozzles that fail to function properly. Replace or repair a slightly bent boom.

b. Remove the old strainers and replace them with new ones. Replace damaged lines, hoses, valves, and gauges.

c. Usually it is not necessary to replace the pump. If the sprayer system loses volume and pressure, it may be necessary to replace the pump, unless the lines are clogged.

d. Brass fittings and nozzles are usually stored in oil to help prevent corrosion.

8. Reconditioning Fertilizer Distributors

a. After all fertilizer material has been removed by using a stiff brush and water, remove the rotor, hopper bottom, and shutter. Repeat the cleaning process on these parts. If some fertilizer material cannot be brushed and washed out, fill the hopper with clean coarse sand and run the distributor with the shutters closed before removing parts. A spin spreader can usually be cleaned with a stiff brush and water.

b. Repair leaks in the hopper or fertilizer box by tightening fasteners or welding leak areas. Remove dents from the hopper or box with the proper tools. Paint or oil unpainted areas on the box.

c. Before replacing the rotor, shape agitators and brush blades to the proper positions. Also straighten dents on the feed shutter and shutter bottom.

Most straightening can be accomplished by using a flat piece of heavy metal and a ballpein hammer. It may be necessary to straighten the blades and fins on a spinner-type distributor.

d. Repack wheel and mechanism bearing. Replace worn bearings and seals. Replace sprockets and other gears that cannot be repaired or those that cause the machine to function improperly.

e. Replace worn belts or damaged chains. Replace v-drive pulleys that show excessive wear or other damage.

9. Reconditioning Fertilizer Applicators

a. Replace valves (liquid outlet, safety, liquid-filling, and vapor return) if they fail to function properly. Most valves are not repairable.

b. Replace the pressure gauge if it fails to show a correct reading after testing.

c. The high and low pressure metering devices regulate the flow of ammonia that is applied per acre; therefore, replace the device that cannot be adjusted.

d. Replace or repair damaged knives and knife shanks. Bent or twisted knives may be straightened by using an anvil, vise, and hammer.

e. Replace main and knife hoses that are cracked or show signs of leaking.

10. Reconditioning Manure Spreaders

a. Wash the spreader in lime water and remove dents from the box. Before washing it is a good practice to remove dirty grease, refuse, and twine from the beaters, chains, and box. Wire brush, old chisel, tire tool, and putty knife make good tools for removing refuse.

b. Remove the drive chains and wash them in a solvent. Clean the chain sprockets in the same type of cleaning solution. Replace damaged links or badly worn chains.

c. Straighten bent beater teeth. Replace missing teeth. The cylinder should be clean before attempting to repair the teeth.

d. Straighten parts of spiral beater or wide spread device and straighten or replace the cross bars on the conveyor.

e. Remove loose bolts and add washers if necessary and replace. Remove, clean, and repack wheel bearings if they are to be serviceable.

11. Reconditioning Cutter Bar and Rotary Type Mowers

a. Cutter bar mower

(1) Remove and straighten the knife assembly by using a hammer and anvil, or place it in a vise and bend it the proper direction.

(2) If it is necessary to remove broken or worn teeth, place the knife section in a loosely closed vise and strike those blades that are to be removed with a hammer. Install new blades on the knife bar.

(3) Grind blades on a leveled grinding wheel. Replace blades that are ground to a point and replace those that are broken or damaged.

(4) Replace guards that are sprung badly. The guards may be sprung up, down, and to one side. Replace the wearing plate, ledger plate, knife chips, and guards if they show excessive wear. Replace ledger plates in one operation.

b. Rotary mowers

(1) Remove knives from mower if they cannot be sharpened on the mower. Knives may be attached to a knife holding strap by pivot bolts. Most mower blades may be sharpened without removing them from the shaft.

(2) Grind the beveled edges by placing the knife lightly against the emery wheel.

(3) Most rotary mowers are equipped with needle, roller, and ball bearings. Replace the old worn bearings with new ones.

(4) Some mowers are equipped with a telescoping drive shaft. Replace the shaft if it is slightly out of line. A bent shaft will cause vibration.

12. Reconditioning Hay Conditioners, Rakes, and Balers

a. Hay conditioners

(1) Replace worn drive belts, gears, and bearings in the crusher mechanism

after the machine has been thoroughly cleaned.

(2) As in other machines, lubricate all parts according to lubrication instructions, and paint those parts that appear worn. Use lubrication instructions to drain and refill each gear case.

(3) Replace springs that show a lack of tension.

(4) Tighten all loose bolts or nuts found on the machine.

b. Side-delivery rake

(1) Remove wheels and repack reusable bearings

(2) Repair old teeth by welding or brazing new extensions on old teeth stubs.

(3) Straighten bent or sprung teeth and bent strippers. If necessary, install new stripper bars. Broken bars can be repaired by welding.

(4) Straighten bent frame parts. Certain parts may be reinforced by welding beads or metal against the damaged part.

(5) Tighten all bolts and nuts on the rake.

(6) Lubricate adjustment and moving parts as recommended by the maintenance manual.

c. Balers - Most baler difficulties are corrected by proper adjustments, but some operation difficulties must be remedied by repair or reconditioning. The baler must be reconditioned before it enters the field. Some major reconditioning jobs are:

(1) Repair or replace pickup teeth. If pickup teeth are not revolving, retighten or replace the drive belt.

(2) Replace worn or broken parts in the wire tying mechanism. Replace the wire-guide rollers if they fail to rotate freely. Replace or repair wire shear plungers. Remove grooves that have been cut by wire on the plate behind twister pinions with a file.

(3) Replace the twine billhook if the twine knot cannot be tied tightly. Replace other tying mechanism parts that are bent, broken, or worn. The billhook may be made smooth by filing; this will eliminate twine hanging on it. Sharp edges found on the disk and twine holder should be removed with emery cloth. Sharpen the twine knife if frayed ends appear at the knot.

(4) Sharpen the slicing knives to give a clean cut bale. The knives may be sharpened with a file on the machine. Some machines have a built-in sharpening mechanism. On some baler models the knives are removed for grinding.

(5) Replace release arm or trip dog spring if the needles do not rise.

(6) Replace worn gears, belts, sprockets, chains, and springs. Most balers are equipped with many of these power transfer parts.

13. Reconditioning Combines

Usually more time is needed to recondition a combine than any other machine. Reconditioning practices are:

a. Replace worn belt and bearing on the reel. Replace damaged reel bats.

b. Repair and recondition the cutter bar in the same way that a cutter bar is reconditioned on a mower.

c. Replace the slats or teeth in the feed conveyor. Some models may use a canvas which must be replaced periodically.

d. Replace the rub-bars if the grooves are not present. In order for the cylinder to remain in balance, all bars must be replaced at the same time. Bent bars may be straightened with a hammer.

e. Straighten the teeth and spike-tooth cylinder with a steel bar. Replace worn, broken, and pointed teeth. Spike tooth concave teeth are usually straightened with a hammer. Broken concave bars must be replaced. The space between the concave and cylinder teeth is recommended in the operator's manual.

f. Remove straw racks and replace those that are worn or broken. If racks are not too severely damaged, they may be repaired. Replace rivets and bolts that have worked loose. The continuous vibration of the rack works rivets and bolts loose. Replace the check flaps if they appear worn.

g. Straighten bent fingers on the chaffer. Broken or damaged slats on the cleaning mechanism should be replaced.

h. Remove dented sieves and straighten the dents with a hammer. Bent valves on an air fan should be straightened.

i. Replace grain pans that have holes in them. It is a difficult job to repair a damaged grain pan.

j. Due to the fact that combines have more belts, bearing, chains, gears, and sprockets than most farm machines, much of the reconditioning time should be devoted to examining these parts and replacing the ones that show wear or damage.

14. Reconditioning Cotton Pickers and Strippers

Reconditioning cotton pickers and strippers is similar to reconditioning several other harvesting machines. These machines have many bearings, belts, chains, bushings, springs, sprockets, gears, bolts, nuts, and screws that must be continuously maintained if the machines function properly.

a. Straighten or replace bent stalk lifters and fingers. Also straighten dented suction and discharge ducts. Straighten dented or bent parts of the frame and cotton basket.

b. Replace dull or damaged spindles. Replace missing moistening pads. Replace worn or bent grid bars.

c. Replace doffer plates if they are bent or badly worn.

d. Repair air leakage in suction pipes. Replace the parts if they cannot be repaired.

e. Clean clogged holes inside the moistening pads. Flush out the water tubes with water. Clean dirty water strainers.

f. Replace or repair stalk lifters and spring fingers. Replace or repair stripping roll or rolls and bar. Also repair damaged conveyor augers. Badly worn brush or rubber strip rolls should be repaired by replacing the brushes or rubber strips.

g. Replace or repair beater fingers on upper and lower beater conveyors on this type of machine. Damaged perforated cleaner screens must be repaired or replaced.

h. Straighten dents and repair parts such as the air deflector, air duct, screen, and conveyor belt on the conveyor (chute) unit.

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1. Phipps, Lloyd J., Mechanics In Agriculture, The Interstate Printers

and Publishers, Inc., Danville, Illinois, 1967

2. Smith, Harris Pearson, Farm Machinery and Equipment, McGraw - Hill Book Company, New York, New York, 1965

3. Stone, Archie A., and Harold E. Gulvin, Machines for Power Farming, John Wiley and Sons, Inc., New York, New York, 1967

4. "Fundamentals of Machine Operation - Preventive Maintenance", Deere and Company, Moline, Illinois, 1973

GENERAL AGRICULTURAL MECHANICS

Unit K: Setting Up and Maintaining Farm Machinery and Equipment

Topic 5: Selecting and Maintaining Various Belts and Chain Drives

Suggested Procedures and Activities: A display of old and new belts and chain drives in the classroom and their use as teaching aids during the class discussion may make the subject more meaningful to the students.

1. Purpose of Belts and Chains

Both belts and chains are made to transmit power but there is considerable difference in their use on machines. Belts are used where high speed is required, but chain drive is necessary where exact timing or exact speed is required. Belts operate quieter or with less noise than chain drives and they require no lubrication. In fact, lubricants, heat, and moisture damage belts. Most chain drives require some type of oil or grease as a lubricant. Belts (flat types) are used where distance is a factor. Usually chain drives are impractical over a long distance. The alignment between shafts must be almost perfect if a chain drive is to operate smoothly. A belt will operate under less perfect conditions.

Transparency No. 1

2. Types of Belts and Their Use

a. V-Belts - These belts are the most widely used types of belts found on farm machinery. They are used on pulleys or sheaves that are spaced close together. As the load increases on a V-belt, the two surfaces grip tighter in the sheave groove.

b. Flat Belts - Usually if a modern machine does not have built-in drives, it operates by the use of V-belts; therefore, flat belts have become less popular. Flat belts are still popular as conveyors. Such belts require large pulleys.

c. Round Belts - These belts are found on farm machinery in a limited number. They are not made to carry heavy loads. Most of these belts are made of solid rubber. Some have cords for reenforcement.

d. Banded V-Belts - Banded B-belts are tied together at the top by a band. The series of belts operate on a series of pulleys. They are usually found on large electric motors that pull heavy loads. Since the belts are permanently vulcanized to a tie band, they will not turn over or jump the pulley while operating at high speeds.

e. Linked V-Belts - This is another type of V-belt which is made to fit drives with fixed centers. Links can be added or removed to fit the distance between drives.

f. Timing Belts - These belts function as a chain drive on sprockets. They are flat belts (top) with teeth that fit into a toothed pulley. The belts require exact alignment of pulleys. There is no slippage with this type of belt.

g. V-Ribbed Belts - V-ribbed belts resemble V-belts and banded V-belts except they operate by friction alone between sheaves instead of wedging found in V-belts. They can be operated at high speed and up to about 10 hp rating.

Transparency No. 2

3. Types of Chains and Their Use

a. Roller Chains - Chains are used where speed is slow to moderate. Forty-five hundred feet per minute (fpm) is considered a good speed for standard pitch chains. Chains with more pitch operate slower. This chain has alternate roller and pin links. They are found on many types of powered machines.

b. Rollerless Chains - These chains operate at a slower speed than roller chains. They are made up of side bar pins and one piece cast links with the links contacting the sprocket teeth. A hinging and no roller action takes place on the sprocket.

c. Silent Chain - Silent chains will run at high speeds (more than 4500 feet per minute). There is very little noise or vibration. It is used as a valve time chain in many types of engines. The parts consist of a series of flat tooth shaped links connected by pins.

d. Detachable Link Chain - This chain was one of the first chains developed for light loads and slow speeds. They were found on many types of early harvesting equipment. Link ends are made in the form of a hook and a bar. They can usually be driven in either direction on sprocket gears.

e. Pintle Chains - This is another light load chain that is used at 450 rpm or less. Links are pitched more than most chains and they are connected by a pin and key. These chains are found on slow moving conveyors.

f. Block Chains - Block chains are made up of cast blocks that are joined by side bars and pins. They like other chains operate on special type sprockets and the rivets (pins) holding the side bars to the cast bars turn in the bores. This type of chain is used on small slow moving conveyors.

Transparency No. 3

4. Determining Belt and Chain Size

a. Most V-belts are marked with some type of code which is usually found on the cover or outside part. The code may show the duty type, width, and length by numbers and letters. For example, a code of 3L305 means 3 strands for a 3/8 inch width, L means light service, and 305 means 30 1/2 inches long.

b. The best method to use when replacing a belt of proper type and size is to purchase a new belt by using figures found on the old belt. Measures taken from the old belt will not be accurate because the old belt has stretched. Do not select a belt that must be pried off or over the pulley sheaves. Excess stress on the belt will break the belt cords.

c. Belts do not necessarily affect power output if they are the proper size and installed properly. Pulleys do affect the power output. The ratio of two pulleys should be 3 to 1 or less. The arc of contact is reduced with a higher ratio, which may cause belt slippage.

d. Another thing that may affect belt usage is proper belt tension. Some belts are longer than the measured distance around two pulleys. These types of belts are controlled by idler pulleys.

e. Chain size is determined by a number which represents pitch inches, width inches, and roller diameter inches. For example, a number 50 chain is 3/8 inch wide, 5/8 inch pitch, and has a roller diameter of .400 inch. Chain width is the distance between side bars, pitch is the distance between rollers, and roller diameter is the measurement across the roller.

5. Problems With V-Belts and Chains

a. Fabric Rupture - Damaged fabric on a belt with this problem cannot be repaired.

It is caused by either tightening the belt too tight, prying or forcing the belt onto a sheave, or by worn sheaves. The solution to the problem is to loosen the belt; always loosen belt tighteners before installing the belt or replacing the belt.

b. Base Cracking - The belt must be replaced with base cracking. A belt cracks with normal aging or the inner fabric rotting.

c. Ruptured Cords - Replace belt if necessary. Do not overload drive. A V-belt that is too tight may also damage the bearings. Lubrication of bearings may prevent bearing seizure.

d. Slip Burn - Burns may be caused from the belt being operated too loose. If the belt happens to grab while operating, it is likely that it will snap. Belts that are operated too slow may burn and the engine may get hot due to the engine fan running too slow.

e. Cover Tear - Cover tears are usually caused by some part of the engine touching the moving belt. The interference should be found and eliminated.

f. Worn Sides - Operating the belt without it being tight enough will cause worn sides. The belt should be checked regularly for proper tension. If the sides are worn badly, the belt should be replaced.

g. Gouged Edge - Some part of the engine can cause this problem if it touches the operating belt. Sheaves that are worn or damaged can cause this condition. Replace damaged belts and locate the cause of damage by inspecting the sheaves and other possible causes.

h. Dirty Belts - Keep belts free of oil and grease which cause the rubber to soften, resulting in permanent damage. Replace soft and damaged belts.

i. Chain Drive Tension - One of the major causes of chain wear is either too much or too little tension on the chain. Too much tension places a heavy load on all working parts including the shaft bearings. If there is not enough tension, the chain has a tendency to vibrate and whip. Long chains are usually adjusted by idler sprockets or guides.

j. Chain and Sprocket Alignment and Meshing - Both chain and sprocket wear if they are misaligned. Another problem in chain and sprocket use is the stretching of the chain which causes it not to mesh with the sprocket teeth.

Transparencies Nos. 3 and 4

6. Checking and Adjusting Belts and Chain Drives

a. A procedure for checking and adjusting belts is as follows:

(1) Check the condition of the belt. If the belt has stretched, worn badly, greasy, cracked and so soft that it rides in the bottom of the pulley, replace it with a new one.

(2) Most operator's manuals will give the amount of deflection certain belts need. Deflection may be determined by using a straight edge and ruler. Simply depress the belt between the pulleys and measure the deflection. Another method recommended is to hook the belt between the pulleys with spring scales and pull outward recording the weight. Ten pounds may be a good figure to use.

(3) The belt must align with the sheaves; therefore, use a straight edge placed on the sides of the sheaves. The straight edge should touch the sheaves at four points. If these points do not touch the straight edge at all times, either the sheaves or shaft is damaged. All damaged parts should be replaced.

b. The following procedure may be used for checking and adjusting chain drives:

(1) Check the chain for too much or too little tension. Too much tension will cause the bearings to wear and place a heavy work load on all working parts. Too little tension will cause chain wear and damage.

(2) Adjust the chain in order that it can be flexed about 2 percent, or a sag of 1/4 inch per foot for horizonal and inclined drives. Vertical drives should be slightly tighter. Fixed shafts or centers' chain tension is adjusted by a third sprocket known as a chain tightener.

(3) Regulate the amount of sag by pulling the chain tight at the bottom of the sprockets. Place a straight edge on top and measure the sag from the bottom of the straight edge to the top of the chain with a ruler. Adjust the tightener or shafts to get the proper tension. Small chains have a tendency to stretch; therefore, it may be necessary to remove a link to make the proper adjustment.

(4) Align chain sprockets and shafts in the same manner as aligning belt sprockets and shafts.

7. Installing Belts and Chains

a. The following method may be used to install belts:

(1) When removing and installing belts always loosen the belt tightener. In some cases a shaft may be moved to give belt slack.

(2) Tighten V-belts as recommended by the operator's manual. New belts will stretch during the first several hours of operation. It may be necessary to readjust the tension. It is usually necessary to use some type of pry to get the proper tension.

(3) If multiple belts are used and one becomes damaged, replace the entire set. It is almost impossible to equally distribute the load with one new belt.

b. One method used to install drive chains is as follows:

(1) If working slack is needed, loosen the chain tightener. Place the chain over a sprocket with links properly fitting the teeth. Connect the ends by inserting chain pins properly. Fasten the pins and properly adjust the chain tighteners.

(2) Check to see if the chain mates with sprocket teeth and lubricate the chain properly before operating the machine.

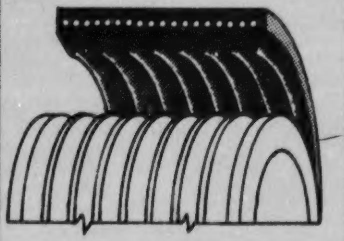
References:

1. "Fundamentals of Service - Belts and Chains", Deere and Company, Moline, Illinois, 1971

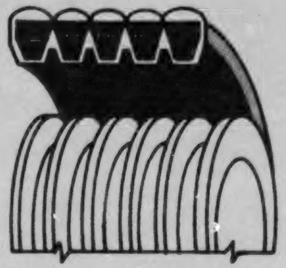
2. "Fundamentals of Machine Operation - Preventive Maintenance", Deere and Company, Moline, Illinois, 1973

3. "Tractor Maintenance - Principles and Procedures", American Association for Vocational Instructional Materials, Athens, Georgia, 1975

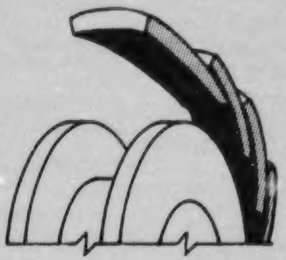
TYPES
OF
BELTS



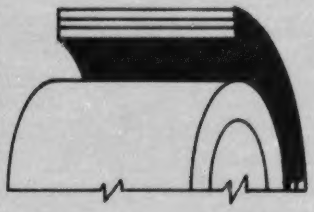
V-RIBBED BELT



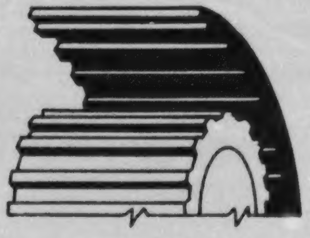
BANDED V-BELT



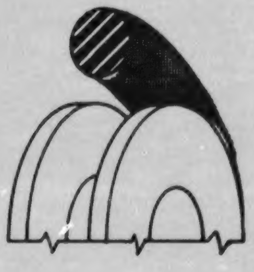
LINKED V-BELT



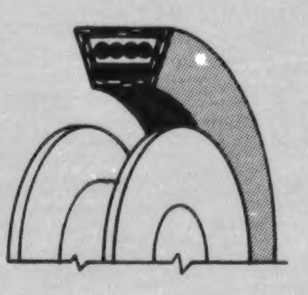
FLAT BELT



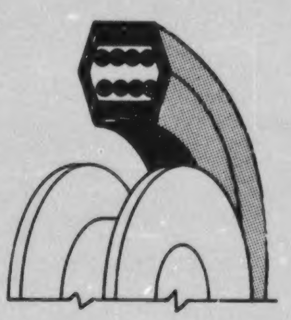
TIMING BELT



ROUND BELT

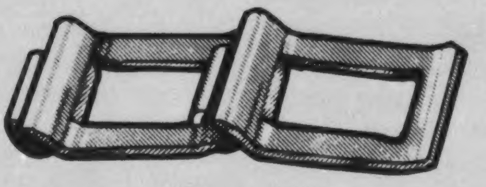


V-BELT

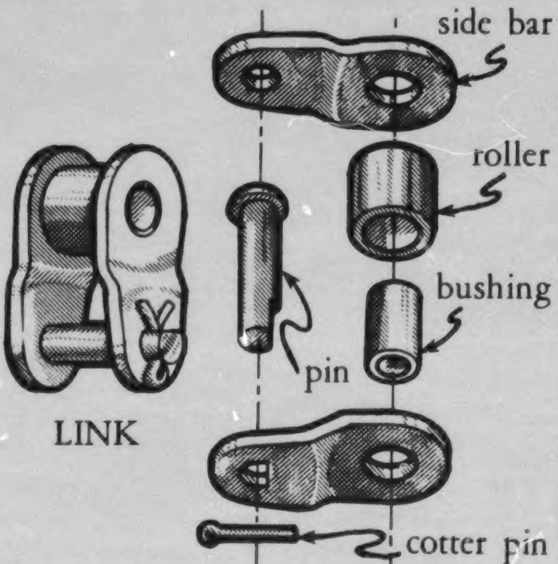


V-BELT

TYPES OF CHAINS

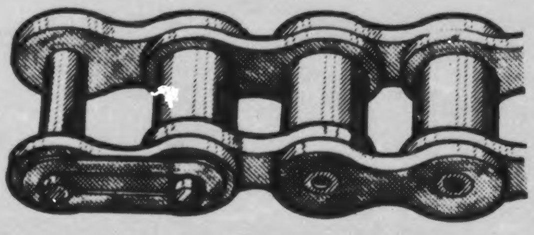


DETACHABLE CHAIN

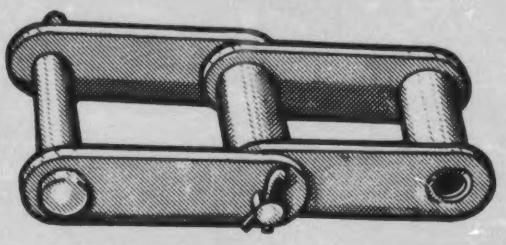


side bar
roller
bushing
pin
LINK
cotter pin

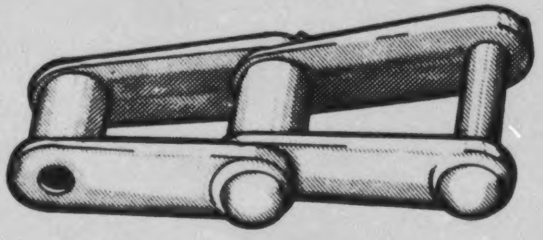
OFFSET LINK CHAIN



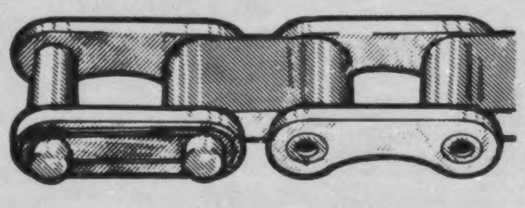
ROLLER CHAIN



ROLLERLESS CHAIN

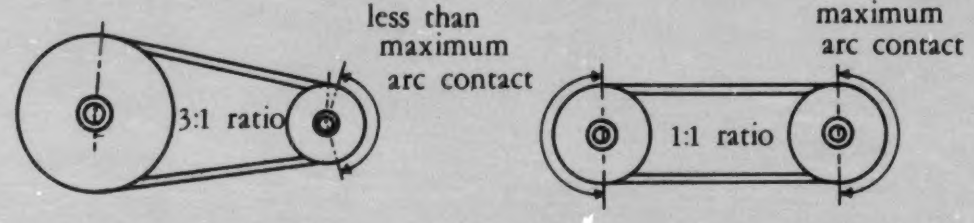


PINTLE CHAIN



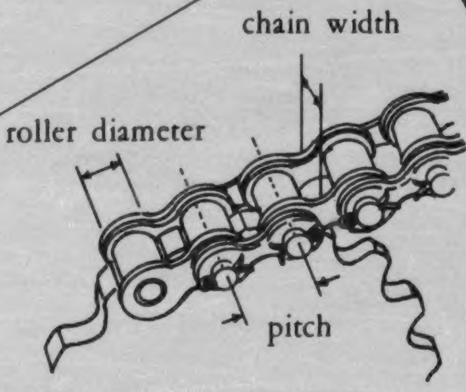
BLOCK CHAIN

DETERMINING BELT AND CHAIN SIZES
MAKING ADJUSTMENTS

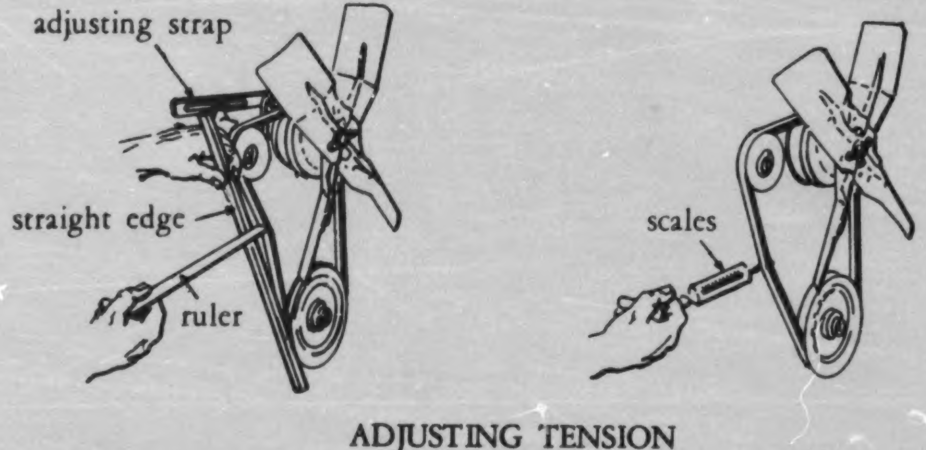

less than maximum arc contact
3:1 ratio
maximum arc contact
1:1 ratio

GOOD RATIO

BETTER RATIO


chain width
roller diameter
pitch

CHAIN MEASUREMENT


adjusting strap
straight edge
ruler
scales

ADJUSTING TENSION

GENERAL AGRICULTURAL MECHANICS

Unit L: Operating Welding Equipment

Topic 1: Arc Welding

Suggested Procedures and Activities: A demonstration on welding two pieces of ice or paraffin together by melting their surfaces may be helpful in explaining the basic principles of arc welding. The use of sample welds and beads will also be helpful while discussing the subject.

1. General Information

a. Arc welding dates back to the latter part of the nineteenth century when experimenters discovered that the arc between two carbon electrodes could be used to melt most metals. The arc, struck between the carbon electrode and the metal, heats the metal to a melting point, then the electrode is removed to break the arc and let the metal freeze or solidify. This flame (arc) of intense heat is generated as the electric current passes through a highly resistant air gap. The air gap is the space between the lower tip of the electrode and the base metal.

b. Arc welding may be defined as the process of fusing two or more pieces of metal together by using the heat produced from an electric arc welding machine. Another way the term may be used - metals are fused together by an electric arc generated between an electrode and base metals.

c. Shielded metal - arc welding is another term used to identify the arc welding process. The coated electrode produces a gas which shields the arc from the atmosphere as the electrode melts. Both the Tig (gas tungsten-arc welding) and the Mig (gas metal-arc welding) yield a gas that protects the welding area from the atmosphere.

d. The advantages of arc welding equipment in the agricultural mechanics shop are:

(1) Scrap metal can be used to make and repair many useful items for home and farm use.

(2) Repairs can be made rapidly on farm machinery and equipment, which is good insurance during harvest time and many other critical periods.

(3) Major cracks or breaks can be repaired on machinery and equipment

before they cause a major repair problem.

(4) Metal repair and construction jobs may be accomplished more economically with an arc welder than with other types of metal repair and construction equipment.

(5) An arc welder can be used for jobs that require cutting, piercing, gouging, and beveling metal.

2. Types of Arc Welding Machines

Transparencies Nos. 1 and 2

a. An AC (alternating current) welder is the most common type for general agriculture use. It ranges in size from 180 to 225 amperes and performs best where the power supply is between 220 and 240 volts.

(1) Advantages of using 180 to 225 amp AC welding machine are:

(a) They are large enough to handle most welding jobs.
(b) The initial and maintenance costs are lower than a welding machine above 225 amperes.
(c) A 180 ampere AC welder has a "limited input" of no more than 37.5 amperes on a 230 volt single-phase circuit.
(d) The 225 ampere welder, being somewhat larger, can handle electrodes one size larger than the 180 ampere welder, and on some jobs the welding can be accomplished somewhat faster. Arc blow is not as great in an AC as a DC machine.

b. DC (direct current) welders are generator-type welding machines that are powered by electric motors, gasoline engines, or other power sources.

(1) Advantages of using DC welders are:

(a) Portable models, powered by engines, can be mounted on trucks or trailers and taken to the work.
(b) Electric power is not necessary for a gasoline powered welder; therefore, they can be used as mobile units for repair work in industry.

(2) DC welders produce direct current of both straight (negative) and reverse (positive) polarity. Polarity is the direction in which the current flows across the arc.

(a) Straight polarity is when the electrode is negative and the work is positive.
(b) When the electrode is positive and the work is negative, the adjustment is reverse polarity.
(c) Cast iron, thin metal, aluminum, and bronze is welded with a reverse polarity adjustment. Mild steel is welded with a straight polarity adjustment.

c. AC/DC welders are essentially welders equipped with a rectifier (an electronic device to convert AC to DC). If the rectifier is not operating, the welder is an AC type.

(1) Advantages of AC/DC welding machines are:

(a) With the rectifier operating, direct current is produced.
(b) The noise usually encountered when operating a DC welder is eliminated with a rectifier.

d. Other types of arc welding processes include laser welding, submerged arc welding, cybertig welding, and electroslag welding. The most commonly used type of arc welding is still the use of a coated electrode (stick electrode) that shields the weld puddle from the air. Burning chemical compounds form a blanket of smoke and gas around and over the molten pool or metal.

3. Selecting a Welder and Other Equipment

a. Select a welder that is made by a reliable manufacturer and sold by a reliable dealer.

b. The dealer should have an adequate supply of protective equipment, operational information, electrodes. Dealers should also be in the position to give prompt service when it is needed.

c. When comparing the prices of welders of equal capacity, check the guarantee on the different machines.

d. The power supply is the most important element in any type of welding machine. Adequate voltage must be available in order to strike an arc and make a good weld; therefore, the power supplier should be contacted regarding the availability of 230 volt service.

e. The arc welder is usually equipped with ground and electrode cables. The cables are fitted with a ground clamp and an electrode holder.

f. Additional welding equipment is as follows:

   (1) Welding helmet equipped with the proper colored glass.

   (2) Blacksmith tongs and pliers.

   (3) Gauntlet type leather gloves.

   (4) Chipping hammer and a wire brush.

   (5) Welding table and a stool or metal chair.

   (6) C-clamps, clear goggles, water can, and soapstone.

   (7) Welding booth or portable screen.

   (8) Power grinder

4. Installation and Maintenance

   a. Have a competent electrician install the welder according to the requirements of the National Safety Code. The welder must be grounded.

   b. The welder should be located in a dry, well ventilated, well lighted place, yet it should be accessible for use on all jobs.

   c. If the cables become frayed, repair them by cutting out the frayed part and reattaching the fittings; never leave the metal cables exposed. Keep all connections on the cables and welder tight.

   d. Blow out dust and dirt from the transformer coils of the welder monthly. Dirty coils cause excessive heating.

   e. Periodically, clean and inspect contractors, switches, relays, and connections, and replace worn or broken parts.

5. Safety Practices to Observe When Using the Arc Welder

   a. Most injuries that are caused by arc welding machines can be prevented if certain precautions are observed. The five major safety items that are of utmost importance are:

      (1) Electrical Shock - The open circuit voltage of an AC welder may not exceed 90 volts, but the electrode holder and welder should always be handled with care. Some of the safety practices include:

- (a) Be sure the welder is properly grounded.
- (b) Secure services of a competent electrician when making an electrical installation.
- (c) Do not run machinery over welding cables.
- (d) Do not stand on wet surfaces when welding.
- (e) Use only electrode holders that are well insulated.
- (f) Wear leather gloves.

(2) Radiant Energy - The arc welding process gives off the same ultra-violent rays as those transmitted by sunlight. The rays given off by the welder are more concentrated than the sun rays. The safety practices to observe are:

- (a) Cover the face and eyes with a shield or helmet before striking an arc.
- (b) Give a warning to all people standing by before striking an arc.
- (c) Examine the helmet for cracks that would let in light.
- (d) Wear protective clothing such as high top shoes, long sleeves, buttoned collars, cuffless pants, and welding gloves. Burns can be caused by wearing improper clothes.

(3) Gases and Fumes - Gases and fumes are usually not a safety problem when welding in a well ventilated shop. A fan may be needed to reduce fumes when welding galvanized metal.

(4) Combustible Materials - Welding enclosed containers which have held combustible materials is very dangerous. There is a definite danger of an explosion unless all precautions are observed.

b. Miscellaneous safety rules

(1) Do not lay an electrode holder on the welding table.

(2) Do not stand on metal that is grounded.

(3) Keep work area clean to avoid falling or slipping and explosions due to dirty area.

(4) Keep tools and equipment in a safe place so they will not fall on the operator.

(5) Do not hold the electrode holder between the knees or under the arm.

(6) If the electrode sticks and cannot be twisted free, cut off switch to the machine; allow electrode to cool and break it loose with pliers.

(7) Do not cool electrode holder in water.

(8) Never rub the eyes if foreign particles get in them.

(9) Do not cut metals on wooden floors. Dripping metal can be caught in a bucket or a pan containing water or sand.

(10) As in welding keep fire extinguisher in welding area.

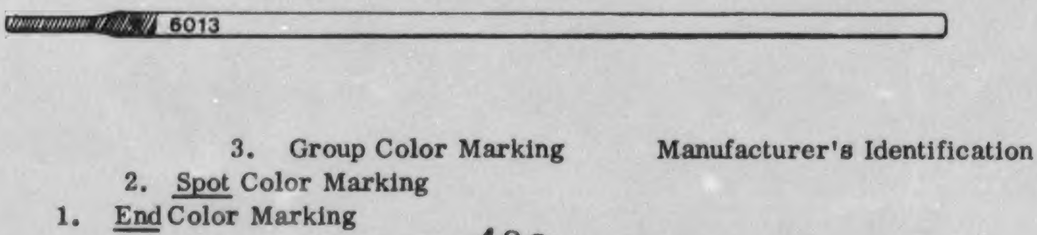
(11) Do cutting in wide open area if possible to prevent hot slag or metal from starting a fire.

(12) After cutting job is complete check the area to see if hot metal has lodged in crevices or cracks.

6. Electrode Classification and Selection

All major manufacturers of welding electrodes use the American Welding Society (AWS) and the American Society for Testing Materials (ASTM) code of specifications. There are several manufacturers of electrodes, and each company makes basically the same quality which is established by AWS. Most electrode manufacturers have adopted the AWS system of identifying electrodes, and that is by numbering each electrode. The National Electrical Manufacturer's Association (NEMA) color code system of identifying electrodes is still used to some extent, but the color coatings or markings should not be confused with trademarks of the manufacturer. Electrodes are classified according to the type of coating, composition of the weld metal, and operating characteristics.

a. Electrodes may be identified by color markings in the following manner:



The meaning of the color code system is explained by the manufacturer. For example, if the spot color is brown this means that the electrode is used to weld mild steel.

b. Identifying some commonly used electrodes by the AWS classification, color markings, manufacturers' numbers and polarity is as follows:

AWS Class	Color Code	Trade Name and/or number	Polarity
E6010	None	Lincoln 5	DC $\overset{***}{-}$ RP
E6011	*E-None**S-Blue	Hobart 335A	DC $\overset{AC}{-}$ RP
E6012	E-None S-White	Marquette 120	DC $\overset{AC}{-}$ SP
E6013	E-None S-Brown	Airco 90	DC $\overset{AC}{-}$ SP
E6014	E-Black S-None	A. O. Smith SW15	DC $\overset{AC}{-}$ SP
E6018	E-Black S-Orange G-Green	Hobart LH718	DC $\underset{AC}{-}$ RP
E6013	E-None S-Brown	Lincoln 37	DC $\overset{AC}{-}$ SP
E6011	E-None S-Blue	Marquette 130	DC $\overset{AC}{-}$ RP

*E - End color marking
**S - Spot color marking
***RP - Reverse Polarity
SP - Straight Polarity

The meaning of the AWS class number (E6013) is:

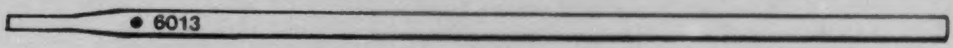
E - The electrode for electric arc welding

60 - The tensile strength of the electrode metal (psi). Example: 60 x 1,000 or 60,000 pounds per square inch.

1 - Weld flat, horizontal, vertical, and overhead. If the third number is a 2, it can be used for flat and horizontal welding, but 3 means flat only.

3 - May mean the chemical analysis of the flux; the polarity of the electrode, AC or DC rating or the penetrating capacity of the electrode. The E6011 will penetrate deeper and have less slag than an E6014 electrode.

c. The size of the electrode to use depends on the job to be performed. The actual size of an electrode is determined by the bare end of the rod.



Specifications for an E6013 Electrode

Standard Size Diameter of core wire	Approximate No. of Electrodes per pound	Standard Length	Amperage Rating
1/16 inch	53	18"	20 - 40
3/32 inch	36	12"	30 - 80
1/8 inch	17	14"	70 - 120
5/32 inch	11	14"	120 - 170
3/16 inch	8	14"	140 - 240

d. One of the main purposes of the flux on an electrode is to furnish a gaseous smoke screen to envelop the arc and protect the molten metal from harmful atmospheric effects of nitrogen and oxygen. The flux coating that does not burn to form the gaseous shield mixes with the metal impurities and settles as slag on the welded metal. The slag may also be considered beneficial to certain types of welds because it holds the heat and keeps the weld from cooling too fast.

e. The three main types of electrodes are:

(1) Coated Electrode - Coated electrodes are used mainly to weld steel. The core is usually steel. If this type of electrode is properly selected, it will have the same or similar properties as the base metal.

(2) Bare Electrode - The bare rod usually requires an excessive amount of heat (10,000 degrees F.) as it passes across the arc. This type of electrode or rod is low-carbon, but it is exposed to oxygen and nitrogen and the oxides and nitrides make the weld hard and brittle. Other characteristics of the electrode include being sensitive to voltage change, electrode angle, and smoke free, which makes the weld visible at all times.

(3) Carbon Electrode - This type of electrode melts slowly while supplying a stable arc. The electrode is used for special types of welding.

f. Electrodes may be classed according to the following special uses:

(1) Mild steel

(2) Cast iron

(3) Alloys

(4) Hard surface

(5) High - carbon steel

Electrode No.	Use
E6010	Used mainly to weld mild steel with a DCRP unit. The penetration is deep.
E6011	Used the same as E6010 except with an AC unit.
E6012	Use with either AC or DC units. The penetration is medium.
E6013	Used on AC, DCRP,or DCSP units. Medium penetration, medium slag, and quiet arc. A good general purpose electrode.
E6020	Used on AC, DCSP, or DCRP machines. The rod has a heavy coating which is high in iron oxide. It is used to weld machine bases and other heavy metal. High amperage gives deep penetration.
E7018	Used on AC and DCRP machines. This electrode is used on high carbon steel which is considered difficult to weld. It has an iron powder coating.

These electrodes can be used in all-position welding. Numbers E6010 and E6011 can be used with ease in the vertical and overhead positions because they solidify rapidly.

7. Preparing Metal for Welding

Transparency No. 3

a. Metal should be thoroughly cleaned before it is welded. Stronger, cleaner, and better-appearing welds are made in less time if the metal is properly prepared. Also, fewer electrodes are used to weld clean metal than are used to weld rusty, unprepared metal.

b. An additional 20 amperes is required to weld rusty or greasy metal than is required to weld clean metal.

c. Metal may be cleaned by brushing, filing, grinding, and scraping. Grinding is considered the best way to clean metal.

Transparency No. 3

d. Proper preparation of the stock is as follows:

   (1) If the pieces of metal are less than 1/4 inch thick, the surfaces may be ground to remove the casting skin.

   (2) Stock that is more than 1/4 inch thick should be beveled at a 30-degree angle. The two pieces of metal placed with the beveled edges together will form a 60-degree angle.

   (3) If stock is beveled on one side or both sides, the unground surface should be 1/16 to 3/32 of an inch thick.

   (4) Metal pieces that are over 1/4 inch thick should be spaced 1/32 to 1/16 inch apart before welding.

8. Regulating the Current and Correct Welding Positions

Transparencies Nos. 4 and 5

a. After the electrode is selected, the welding machine amperage should be set to get a good penetration with a minimum of spatter. The amperage setting is determined by thickness of metal, size of electrode, speed of travel, and position of weld.

b. If the amperage is too high, the bead will be flat and porous; and the edges will be spattered. If the amperage is too low, the metal will pile up making a high, narrow bead. A bead, welded with low amperage, will not have the proper penetration.

c. The approximate amperage, size of electrode, and thickness of metal is given below:

Suggested Amperage Setting

Approximate Amperage	Size of Electrode	Thickness of Metal
65	3/32"	1/16"
80 - 100	3/32"	3/32"
80 - 100	1/8"	1/8"
115 - 130	5/32"	3/16"
130 - 150	5/32"	1/4"
140 - 150	5/32"	5/16"
160 - 175	5/32"	3/8"
175 - 200	5/32"	1/2"

Alternating current (AD) is different than direct current (DC); in that there is no polarity adjustment to make for welding. The alternating welding current reverses many times per second while the welder is being used.

d. Correct welding positions (a left-handed person should reverse the procedure) include:

(1) Sit or stand in a relaxed position to avoid fatigue.

(2) Hold the electrode holder in the right hand. Place the left hand on the underside of the right hand.

(3) If in a sitting position, put the left elbow on the left knee. This position braces the body, yet it still permits free movement.

(4) Hold the electrode holder firmly and weld with both hands, if possible.

(5) The movement of the electrode should be from left to right.

(6) The position of the electrode should be in line with the weld and leaning at about a 15-degree angle to the metal or in the direction of travel.

9. Starting the Arc

Transparency No. 6

a. An arc is formed in a circuit when the electrode is brought in contact with the metal surface and then withdrawn slightly. The current jumps this gap and makes an arc hot enough to melt the metal surface and the electrode.

b. Two methods of striking an arc are as follows:

(1) Tapping method

(a) Set the welding machine to the correct current.
(b) Bring the tip of the electrode straight down and tap it on the metal surface.
(c) After striking the arc, hold the electrode tip between 1/8 and 1/4 inch above the stock to allow the arc to become established before starting the weld. Begin welding with the tip 1/8 inch above the botton of the crater.
(d) Tilt the electrode about 20-degrees from vertical in the direction of travel to make the weld.

(2) Scratching method

(a) Set the welding machine to the correct current.
(b) Bring the tip of the electrode down in a sweeping motion (the motion for striking a match).
(c) Raise the electrode 1/8 inch at the end of the sweeping motion.
(d) As the molten crater forms, maintain the 1/8 inch distance between the tip and the bottom of the crater.
(e) Tilt the electrode 15-degrees for making the weld.

c. The correct arc length may also be determined by sound. When the arc is too long, it will give off a bellowing sound. If the arc length and amperage are correct, the arc will give off a continuous crackling or frying sound. A very short arc will produce a muffled popping sound.

d. The correct arc length will eliminate excessive spattering, overlapping, and undercutting. It will give fairly deep penetration with the proper fusion of metals.

e. If the electrode sticks to the plate or stock, it should be broken loose with a quick twisting or bending motion. If it becomes welded to the plate, disengage the holder and break it loose with pliers.

f. Causes of difficulties in starting an arc:

(1) Flux coating is chipped on the electrode tip. A fast scratching method and finishing the sweep with a long arc is the best way to strike an arc.

(2) The work is improperly grounded. Arcing may occur where ground clamp is attached to the metal. Metal should be clean where clamp is attached.

(3) Improper electrode contact in the holder jaws. The holder may have a weak spring, foreign material in the jaws, or the jaws may be holding the electrode by the flux coating.

(4) Failure to use the correct electrode for the recommended amperes or metal stock.

(5) Loose connections between the cables and welder terminals. Loose and dirty connections may reduce the electrical efficiency of the welder.

10. Steps in Laying a Bead

Transparencies Nos. 7 and 8

a. Before laying a bead, the welding machine should be adjusted to the proper amperage. For example, a 1/4 inch plate can be welded with an 1/8 inch or larger electrode at an amperage setting between 80 and 110; but if a 3/8 inch plate is welded, more heat is needed to bring the metal up to a molten stage. A 5/32 inch electrode and an amperage setting of 160 is recommended to weld a 3/8 inch plate. Another way to adjust the amperage setting is set the current to correspond to the diameter of the rod. The measurement is in thousandths of an inch and only includes the metal part of the electrode. Example: A 1/8 rod measures .125; therefore, the machine will be set to operate at about 125 amperes + or -. A 5/32 inch electrode measures .156 inch so the amperage setting should be 150 plus or minus a few amperes.

b. The second most important step is to hold a long arc until the base metal begins to melt, and continue to watch the puddle instead of watching the arc.

c. After the metal begins melting, the electrode should be brought down to form the proper arc length and the top slanted toward the line of weld for running a bead.

d. Maintaining a good puddle is one of the most important steps in making a good weld. The puddle should be about 1 1/2 times as wide as the width of of the electrode. The slag should not flow in front of the puddle.

e. In order to maintain a good puddle, the speed of travel must be adjusted to permit a desired bead height. Usually, welding a heavy plate requires a slower speed than welding a thin plate.

f. If the arc is broken while running a bead, it should not be started in the same place (the crater of the interrupted bead). It should be started on the metal ahead of the crater. The weld passes back through the crater toward the bead and then back over the same path in the line of weld.

g. The best way to fill a crater at the end of a bead is to push the end of the electrode down into the crater, almost to the sticking point, and pull it away quickly to break the arc.

h. The electrode movements for laying a weld bead are:

  (1) The two main movements are the downward feeding of the electrode to maintain the desired arc length and the movement along the weld line.

  (2) Crescent weaves are used to strengthen welds by making a better quality of weld. The most common types of crescent weaves are:

    (a) Back-and-forth motion with a slight arch (easiest to use for inexperienced welders).
    (b) Back-and-forth motion with a slight arch and a V at the end to work the metal into the edges.
    (c) Back-and-forth motion with semicircular round ends; used for vertical and overhead welding.

  (3) Circular weave is used for vertical and overhead welding.

  (4) The straight back-and-forth weave is used mainly for flat surface welding. A "V" or leaning N is formed in this weave.

  (5) The whipping weave is used by the more experienced welder. This type of weld permits a deeper penetration and allows gas and slag to surface.

11. Padding or Building Up and Weaving

Transparency No. 9

Weaving should not be practiced until the skill of running a bead has been more or less perfected. Padding gives the individual the opportunity to practice running a bead.

a. Padding steps are:

   (1) Begin welding a bead in the upper left-hand corner of the plate; maintain the bead longitudinally flush with the upper edge of the plate while moving from left to right.

   (2) Both ends of the weld must be flush with the edge of the plate; therefore, the crater should be filled at the end of the bead.

   (3) Chip and wirebrush the bead until it is perfectly clean before laying another bead along its side.

   (4) Place the second bead so that it will fuse with one-fifth of the first bead.

b. Repeat each padding step until the entire surface of the plate or area is completely covered with deposited metal and is flush on all four sides.

c. The welding operator should learn the different positions for welding under different welding conditions. The arc cannot be moved from left to right at all times. The other three positions include:

   (1) Without changing the position of the practice plate, begin at the lower left-hand corner and lay the bead away from the body. Use steps 2, 3, and 4 for padding. Cover the entire plate and brush clean for the next layer.

   (2) Deposit a third layer without moving the plate, but move the arc from right to left. Again, use steps 2, 3, and 4 for padding. Brush all beads clean before starting the fourth layer.

   (3) Add the fourth layer with the steel plate in the initial position. Clean the plate so that the beads can be examined.

d. The steps to use for practicing weaving are as follows:

   (1) Use a piece of soapstone and mark parallel lines on the plate at 1/2 inch intervals.

   (2) Weld beads along the marked lines, spaced at 1/2 inch intervals; chip and brush the beads clean.

   (3) If a 1/8 inch electrode is to be used on a 1/4 to 3/8 inch thick

plate, the amperage should be raised from 100 to 110 or 115. It takes more heat and a larger puddle for a wide bead than is required for a narrow bead.

(4) With coated electrodes use a flat semicircular motion, hesitating briefly at each side to avoid under cutting.

(5) Fuse the wide bead into the straight bead at 1/5 the width of the straight bead. The height of the wide bead should be uniform in height over the entire plate.

12. Types of Welds and Weld Joints

Transparencies Nos. 10 and 11

a. The two types of joints most commonly used on arc welding are the butt and fillet welds. The following numbers (1) and (2) are butt welds and numbers (3), (4), and (5) are fillet welds:

(1) Square Joints - These joints are unbeveled if the metal is less than 1/4 inch thick, and the two pieces are spaced about 1/2 their thickness apart to permit good penetration.

(2) Single Beveled and Double-Beveled Joints - These joints insure penetration and fusion of the metals. The pieces are also spaced apart for welding purposes. Metal that is more than 1/4 inch is usually beveled.

(3) Tee Joints - The T joints are made by placing two pieces of metal together to form a T. The two pieces are welded together with one or more passes of a fillet weld.

(4) Lap Joints - One piece of metal is placed over the other, and they are joined together by welding the ends.

(5) Corner Joints - The corners, forming a groove with a 90-degree angle, are placed together at right angles.

13. Steps Used When Making Butt and Fillet Welds

Transparency No. 12

a. Butt welds in the flat position are most commonly used. Most broken parts of machinery can be repaired by a butt weld. Butt welding steps in the flat position are:

   (1) Place two pieces of metal side by side leaving a 1/16 inch space between the two pieces for thin metal and 1/8 inch space for heavy metal.

   (2) Tack weld each end of the prepared pieces. Tacking is to prevent warping while the metal is being welded.

   (3) If the metal is beveled, start the pass in the groove on the tack weld. Use a very short arc for the first pass. The electrode lead angle can be as much as 45-degrees.

   (4) If an unbeveled metal plate is being welded, it should be tacked and a welding pass made from both sides of the plate. A steel strip may be used if the joint cannot be fitted.

   (5) The first (root) bead is made without a weaving motion of the electrode. The future passes are made by a crescent weave, but between each pass the prior bead or weld is cleaned before making the next pass.

   (6) If a crescent bead is used, the arc must be hesitated on each motion at the edge of the groove in order to build up the edges of the bead.

   (7) On the last pass, a weaving motion must be used on heavy metal to obtain a reinforcing cover over the preceding beads.

Transparency No. 13

b. Fillet welds are used to join two surfaces that meet at right angles. Flat fillet welds are very easy to make if the two pieces of metal to be welded form a "V" in the up position. Fillet welding steps in the flat position are:

   (1) Place two pieces of plate metal together forming a "T" (upside down); tack both ends of the pieces to prevent distortion.

   (2) The electrode may either be placed in the electrode holder at a 45-degree angle, or the electrode may be held at a 45-degree angle from each side of the plates when making a welding pass.

The electrode should also be pointed into the joint with a 15-degree lead.

(3) Move the electrode steadily along the seam at a rate that allows the weld puddle to penetrate each piece of metal. A side-to-side motion is not necessary on the first pass. If a 5/32 inch electrode is used, one inch of weld should be laid for each inch of electrode used.

(4) The second pass is made after cleaning the slag from the bead with a wire brush. The second bead should be laid on the flat surface against the first bead. Slag is removed from the second bead.

(5) The third pass is laid on top of the first pass and against the vertical plate. It also penetrates the edge of the second pass. Slag is removed from the third pass.

(6) If it is necessary to lay additional passes, the fourth bead should be laid at the bottom, the fifth and sixth beads should follow to complete the weld.

(7) Welding speed can be increased and undercutting reduced if a "T" joint is welded in a "V" position. The arc should be short and the electrode must be held in the center of the "V" to make a good weld. Weaving may be practiced if more than one bead is laid.

(8) When welding thin metal to heavy metal, the angle of the electrode should be about 60 degrees from the heavier metal.

(9) The bead(s) should be cleaned and checked for uniformity and penetration.

14. Other Position Welding

a. The three different types of position welds are referred to as vertical, horizontal, and overhead. The vertical weld is used more than the other two.

b. The difficulty encountered when making an out-of-position weld is the control over the molten metal in the puddle. The puddled metal has a tendency to fall from the puddle. General practices to follow when making a position weld are:

(1) Use an amperage setting that will permit the highest current possible for handling the thickness of the metal being welded. Usually, lower

amperage is used for position welding rather than flat welding. It is necessary to try several amperage settings in order to locate the correct amperage.

(2) The electrode should be placed in the proper position for the weld.

(3) Strike the arc and hold it shorter than is required for flat position welding.

(4) Begin by moving the electrode slowly until the molten metal will no longer remain in the puddle; increase the speed until a desired build-up of metal is obtained. The metal will solidify before dropping off if the correct speed is used.

(5) Use the proper size and type of electrode. AWS No. E6011 electrode is suited for position welding. Electrodes of smaller diameter are easier to control than large diameter electrodes.

(6) After the bead(s) are laid, they should be cleaned and checked for uniformity, sags, craters, penetration, and width.

Transparency No. 14

c. Vertical Welding - The two most commonly used methods of vertical welding are "vertical-up" and "vertical-down". The steps for making the welds are:

(1) Light metal is easier to weld than heavy metal. For example in order to get the "feel" of position welding, use metal 1/8 inch thick and an electrode 8 inches long; set the amperage between 60 to 80.

(2) Place the metal plate in a vertical position and secure before starting the weld.

(3) Place the electrode in the electrode holder. Position it at an angle of 60 degrees to the plate and in the path of the weld. The electrode should be perpendicular to the sides of the plate.

(4) Begin welding at the top of the plate with a very short arc. If the electrode sticks to the plate, increase the amperage. If a "burn through" is repeated several times, lower the amperage or increase the speed downward.

(5) When welding vertical-up, place the electrode in the electrode holder so that it may be held at about 90 degrees to the metal in the path of the weld.

(6) Weld thick metal by using one or more side-to-side motion passes.

Transparency No. 15

d. Horizontal Welding - This type of weld is used to butt weld plates or make repairs in the horizontal plane position. The welding steps are:

(1) Secure a plate in a position for running beads in a straight line from left to right.

(2) Place the electrode in the holder so that it can be held at 90 degrees from the plate sides. Lean the top of the electrode slightly toward the area to be welded.

(3) Bevel metal pieces over 1/8 inch thick before welding them together in the horizontal position. Tilt the electrode according to the pass and bevel when welding thick metal.

(4) Adjust the amperage, speed, and length of arc to prevent excessive sagging.

(5) When welding thick metal that has been beveled, more than one bead or a weaving bead should insure a stronger weld.

Transparency No. 16

e. Overhead Welding - Overhead welds are made similar to flat position welds, except they are much more difficult to make than any type of weld. The major difficulties are to maintain a short uniform arc and protect the body from molten metal. The overhead welding steps are:

(1) Secure the metal plate above the head when in the standing position.

(2) Protect the body by wearing protective clothing. (Heavy jacket with long sleeves and tight collar.)

(3) Place the cable on the shoulder and hold the gloves in a position to prevent sparks from entering them.

(4) Place the electrode in the holder to permit the most comfortable position for welding.

(5) Use a 1/8 inch or 5/32 inch rod, and the same amperage setting that is used for vertical welding. If the electrode sticks, increase the amperage.

(6) Weld with a short arc and a moderately fast rate of travel to prevent sagging and undercutting.

(7) Use a weaving pattern on heavy metal. The weaving motion must be somewhat faster than other position welds.

15. Welding Various Kinds of Metals

a. Cast Iron - This metal is very difficult to weld. It expands, contracts, and even crumbles under certain heating conditions. As the metal cools, cracks may appear in or near the welded area. The two types of electrodes for welding cast iron are:

(1) Nickel or copper - core electrodes are used to weld cast iron to steel. The major purposes of using these types of electrodes are:

(a) The metal s are machinable.
(b) The casting(s) do not require preheating.
(c) The cooling speed does not have to be controlled.
(d) The electrode is more expensive than a steel-core electrode; but in nearly all cases, the cost of the weld is less expensive.

(2) Steel-core electrodes are not recommended for malleable cast iron. Preheating and controlled cooling is necessary if steel-core electrodes are used. Also, the weld cannot be machined when using this type of electrode.

b. Sheet Metal - Observe the following practices when welding sheet metal:

(1) Use low amperage and weld as rapidly as possible to prevent burning a hole in the metal.

(2) Use an electrode no larger in diameter than the thickness of the metal.

(3) Use a short arc.

c. High Carbon Steel - High carbon steel becomes brittle if it is cooled very rapidly. Welding practices include:

(1) Preheat the metal to a blue color and maintain this color throughout the weld.

(2) Use a mild steel electrode and lower amperage than is used for welding mild steel.

(3) Allow the metal and welded area to cool slowly.

16. Arc Welder Cutting

Transparency No. 17

a. The arc welder is not a metal cutting machine, but metal can be cut, pierced, or gouged if the proper procedure is used. The electric arc can be used to cut steel, cast iron, and many nonferrous metals. More fumes are produced from cutting than welding; therefore, the cutting area should be well ventilated. Fumes from cutting galvanized metals, lead, brass, bronze, and painted metal can be dangerous if inhaled.

b. Some steps to follow in cutting metal include:

(1) Select a mild steel (E6011) electrode 1/8" to 3/16" and use a welding current at 160 to 180 amperes. Soak the electrode in water for about 10 minutes. An electrode that has lost its coating should not be used.

(2) After arranging a sand pail to catch the molten metal, start the cut at the edge or corner of the base metal. The area to be cut should be extended over the edge of the welding work table. Use the electrode in a similar manner as a chisel; push the electrode up and down and move it slowly along the line to be cut. The upward stroke arc is long to cut the metal and the downward stroke arc forces the molten metal out.

(3) To pierce rough holes in metal less than 1/4 inch thick, use the following method:

(a) Strike the arc and hold it in one spot until the metal begins to melt. The electrode should be held at a 90-degree angle to the surface for cutting a straight hole.
(b) Push the electrode down at a rapid rate or as rapidly as possible as the metal continues to melt.

(4) Cutting bevels can be accomplished by using the arc welder but a much neater job is realized when using a grinder or oxyacetylene cutting torch. If it is necessary to use the arc welder for beveling, the following steps may be used:

(a) Lean the electrode in the direction of the bevel. The angle between the electrode and metal should be the same angle as found on the finished bevel.
(b) Hold the core of the electrode near the metal and move the electrode in the direction of the cut as the metal is blown from its path of travel.

17. Hard Surfacing

Transparency No. 18

a. Hard surfacing, sometimes called hard facing, is the process of applying a layer of wear-resistant metal to the surface or cutting edge of a part to increase its life.

b. Hard surfacing is mainly used to repair worn edges of farm equipment, such as plowshares, cultivator sweeps, harrow spikes, and planter shovels.

c. The steps for hard surfacing are as follows:

(1) Grind the surface free of rust and scale.

(2) Select an abrasive work-hardening electrode and set amperage between 75 and 100 degrees for a 1/8 inch electrode or 130 to 140 degrees for a 5/32 inch electrode.

(3) Apply the hardening metal in even thin layers by using a weaving bead no wider than "1 inch".

(4) Remove slag before laying additional beads.

(5) A certain amount of shaping can be done by grinding, but if there is excessive build-up, shape the metal by heating and forging.

(6) The steps in hard surfacing a plowshare are:

(a) Run the beads from the heavy part toward the point on the underside (ground side) and parallel to the cutting edge.
(b) Lean the electrode at about a 30-degree angle with the burning point in the direction of the plowshare point.
(c) Lay weaving beads side-by-side until the cutting surface is covered. The layer must be smooth.

(d) If necessary, peen the deposited weld metal as it cools.

d. The steps for hard surfacing a thin cutting edge are as follows:

(1) Apply hardsurfacing powder in a layer twice as thick as the finished deposit. This powder can be applied dry or as a paste, and it should cover the entire area that needs to be hardened.

(2) Use a carbon arc torch (carbon arc attachment may be used on AC or DC welder) in a circular motion to fuse the powder to the base metal. Carbon arc welding is usually done on a flat surface because the flame cannot be blown into a recessed area.

Transparency No. 19

18. Pipe Welding

Pipe welding is not necessarily a special type of welding. In fact, the same welding procedures are used for making butt and fillet welds on flat plate. It may seem more difficult, but the skill can be successfully mastered after mastering the common welds. It is more difficult to prepare some pipe joints for welding than preparing flat surface metal.

a. Procedure for making different types of pipe joints are as follows:

(1) Ell Joint - Pipe may be marked at a 45-degree angle by using outside even numbers on the tongue and blade of a framing square or by using a T-bevel square set at a 45-degree angle. Chalk or soapstone serve as good marking tools. The pipe is cut along the line, and finished joints are cut on a grinding wheel.

Butt the joints together and weld from point to heel, after tacking the joints together. If welding is performed from heel to point, the heat will be more difficult to control, which may cause burn-through.

(2) Tee Joint - If the joint is made to carry a liquid, cut a hole in the header pipe and grind the branch pipe to fit the header pipe. The area to be cut on the branch pipe can be marked with chalk or soapstone by placing the branch pipe on the header pipe to make the proper arc. The pipe should be tack-welded in four places. Start weld at the center (high point on arc) and weld

toward the 90-degree angle formed by the two pipe pieces.

If the pipe is not used to transfer liquid then it is not necessary to cut a hole in the header pipe or to cut an arc on the branch pipe, but it is necessary to flatten the end of the branch pipe on two sides; tack it to the header pipe and weld.

b. Some suggestions for bending and welding pipe are:

(1) Bend small diameter pipe by using a pipe bender, a bending jig, or two fixed studs. Begin bending at one end and bend slightly every inch or two. To prevent flattening thin walled tubing, fill it with sand and plug the ends. Heavy pipe can be bent if it is heated. Wrinkle bending may be used on pipe over 1 1/2 inches in diameter. Wrinkles will form on the underside of the bend.

(2) If the ends are to be welded either a flat plate can be welded over the end or scallops can be cut, heated,and bent in so they may be welded together.

c. Pipe welding positions are:

Roll Welding - The weld is started one-fourth of the way down from the top of each side of the pipe. The torch tip is pointed upward. This torch position is used in vertical welding. The pipe is rolled one-fourth turn, a second weld is made, and the procedure is continued until the four welds are completed.

Position Welds - The pipe is in a stationary (fixed) position; therefore, the weld is made by beginning at the bottom and moving to the top on each side of the pipe.

The steps to follow when welding a pipe are:

The opening in pipe smaller than 2 inches in diameter is too small to insure good fusion. It is usually not necessary to bevel small pipe. Three-inch pipe should be beveled and the ends should be spaced apart slightly over 1/8 inch.

Clamp the pipes in position for tack welding. Remove the clamps after the tacks are completed. Small pipe may require three tack welds, whereas large pipe (6 inches or more) may require five tack welds. Tack welds may be made about one inch long.

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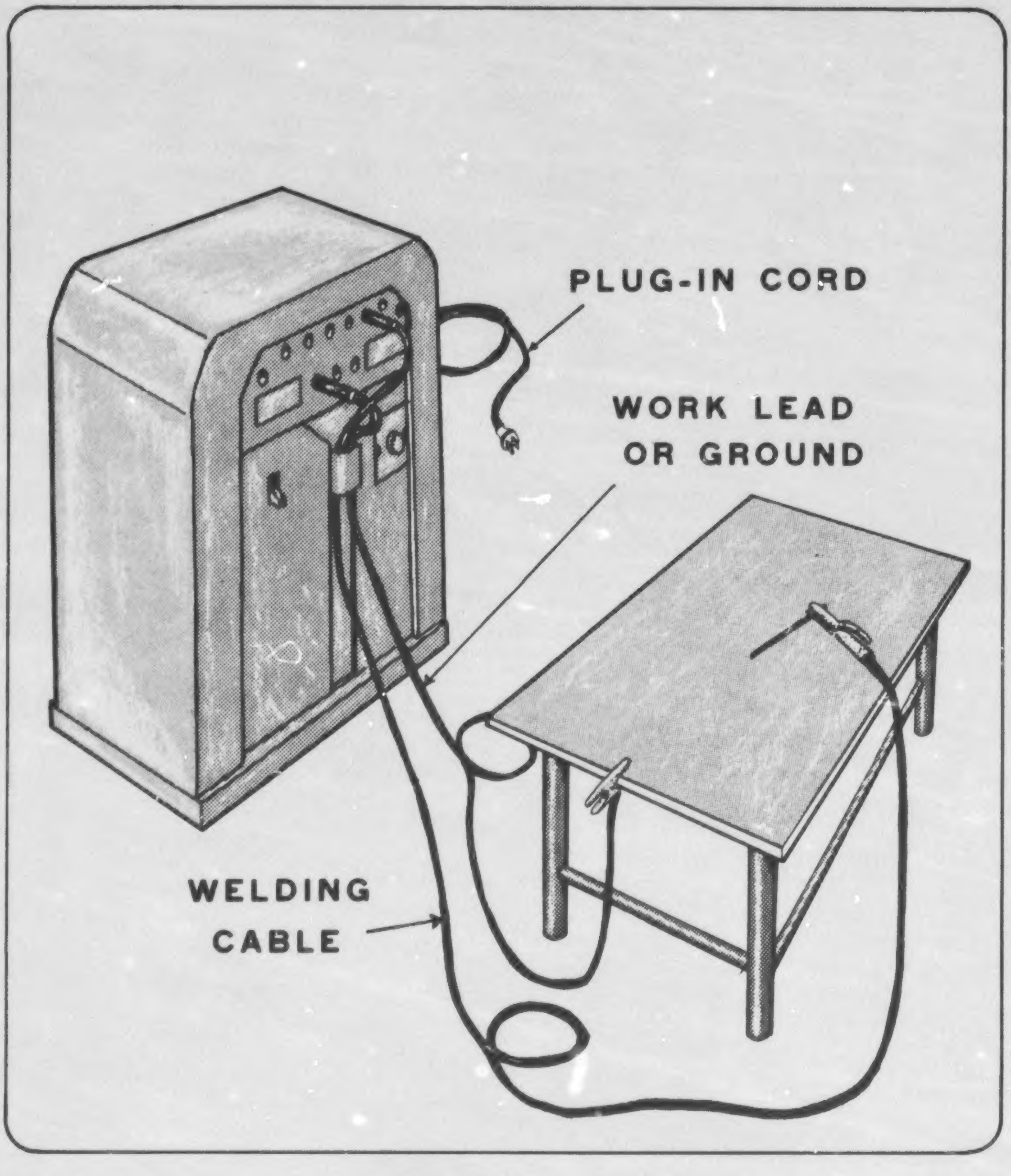
AC ARC WELDING MACHINE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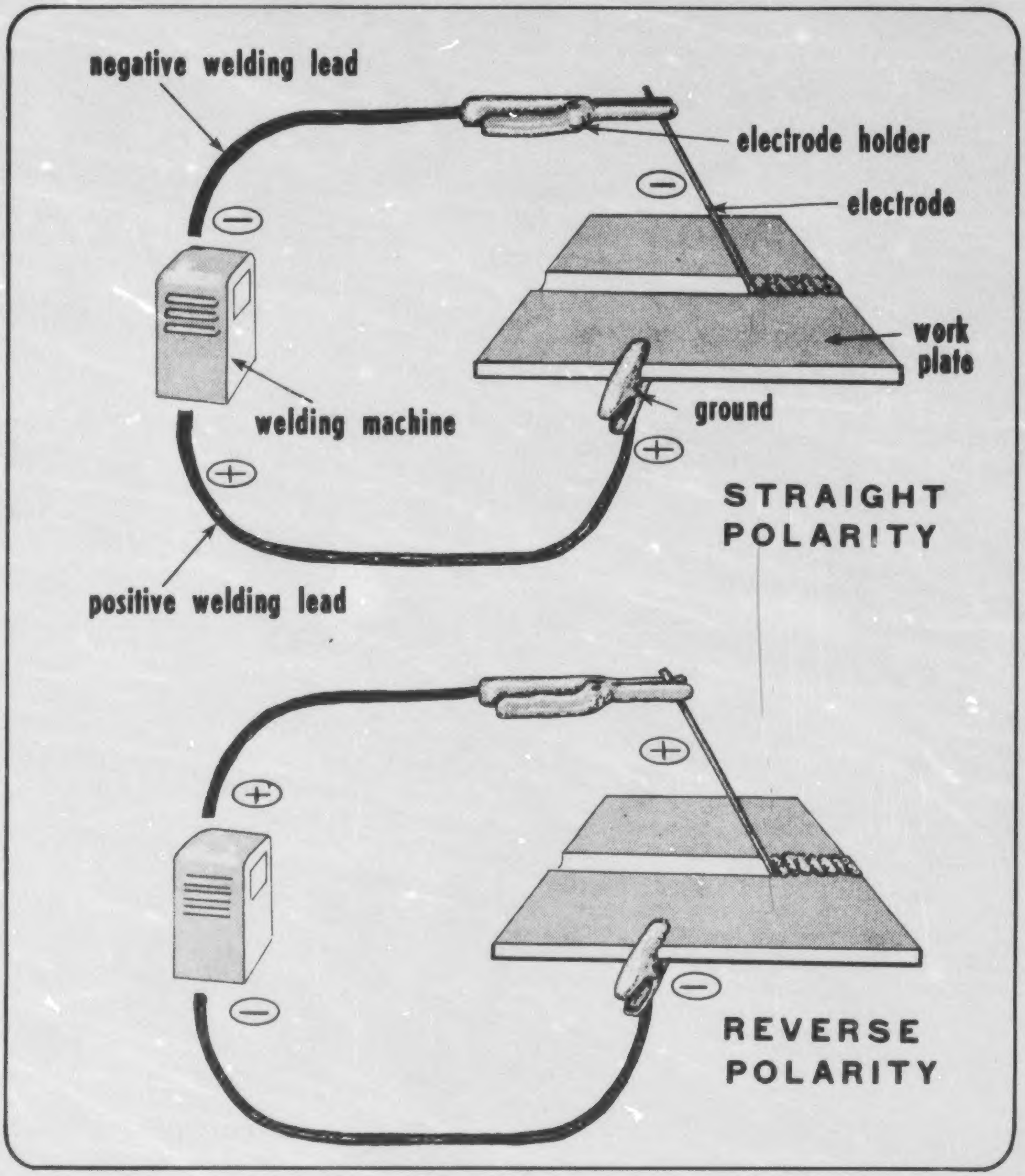
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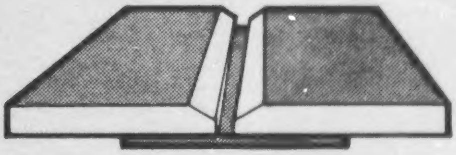
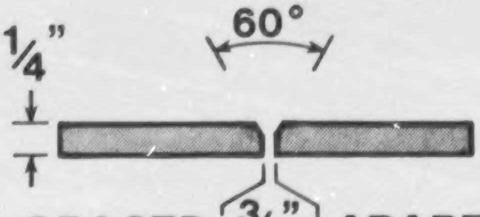
STRAIGHT POLARITY
REVERSE POLARITY

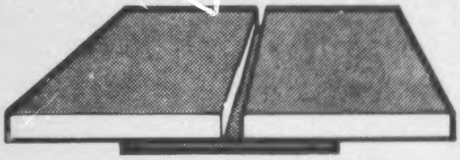
PROPER PREPARATION OF STOCK



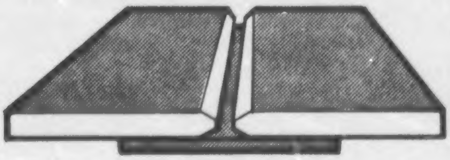
ONE SIDE BEVELED



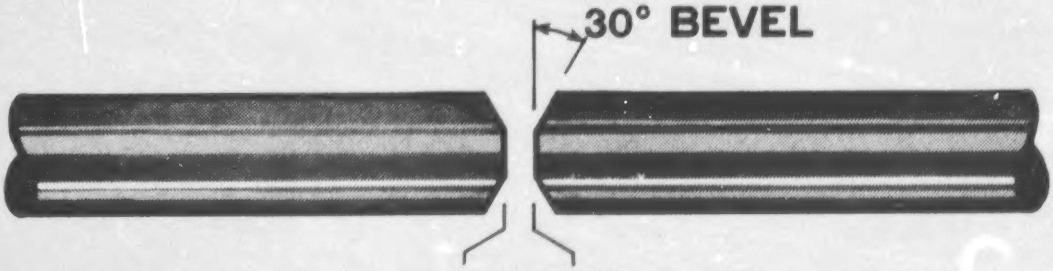
SPACED 3/32" APART



JOINT WITHOUT BEVEL

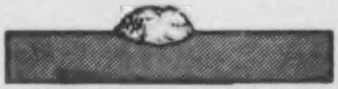


TWO SIDES BEVELED

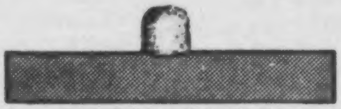

30° BEVEL
1/16"–1/32" OPENING

ROUND STOCK BEVELED ON TWO SIDES

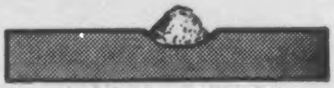
ADJUSTING THE CURRENT



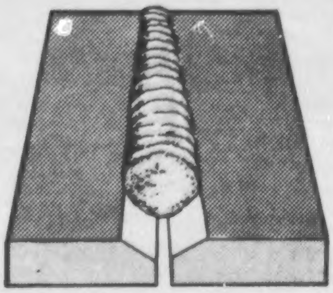
NORMAL BEAD



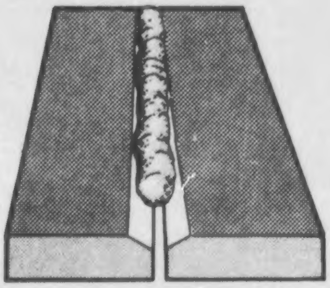
HIGH BEAD
(low penetration)



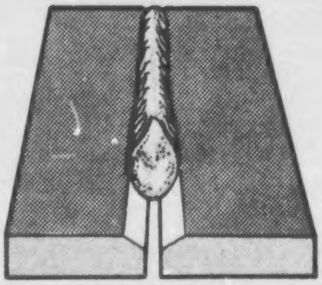
LOW BEAD
(under cutting)



CORRECT AMPERAGE



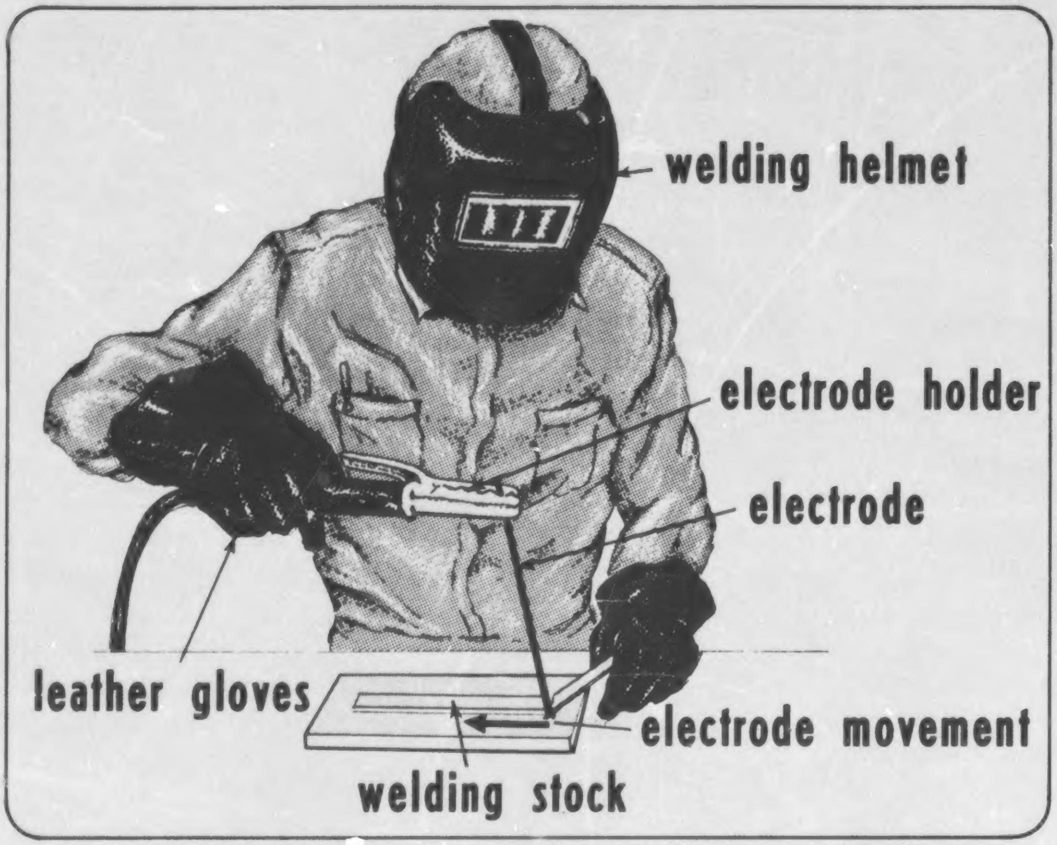
LOW AMPERAGE

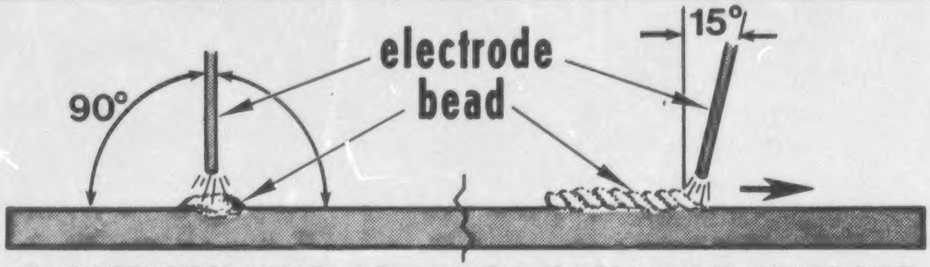


HIGH AMPERAGE

AMPERAGE	ELECTRODE SIZE	METAL THICKNESS
65	3/32"	1/16"
80-100	3/32"	3/32"
80-110	1/8"	1/8"
115-130	5/32"	3/16"
130-150	5/32"	1/4"
140-150	5/32"	5/16"
160-175	5/32"	3/8"
175-200	5/32"	1/2"

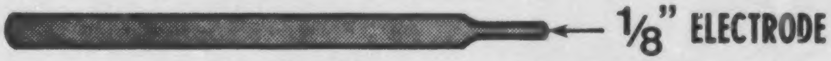
WELDING PROCEDURE

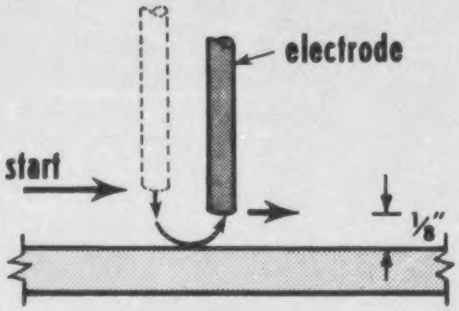

welding helmet
electrode holder
electrode
leather gloves
electrode movement
welding stock


15°
electrode
bead
90°

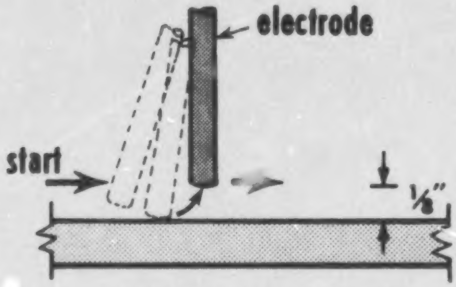
ELECTRODE HELD AT 90° TO EACH SIDE OF PLATE AND 15° IN DIRECTION OF TRAVEL

STARTING THE ARC

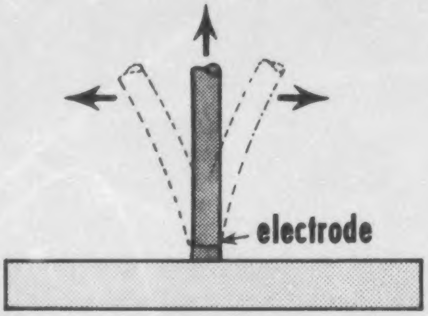

1/8" ELECTRODE


electrode
start
1/8"

TAPPING METHOD

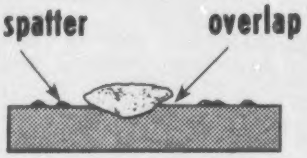

electrode
start
1/8"

SCRATCHING METHOD

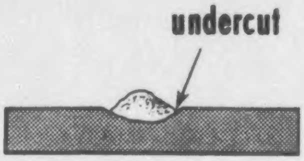


STUCK ELECTRODE IS BENT FROM SIDE TO SIDE AND PULLED UP

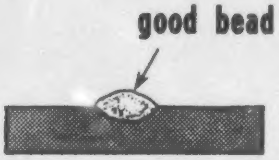
LAYING THE BEAD


spatter
overlap

POOR PENETRATION

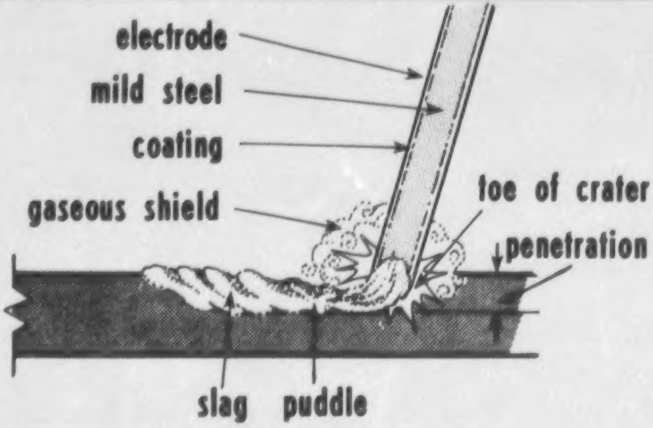


DEEP PENETRATION

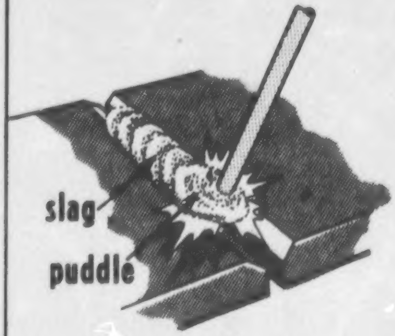


PROPER PENETRATION

STEPS IN RUNNING A BEAD

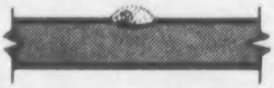

electrode
mild steel
coating
gaseous shield
toe of crater
penetration
slag
puddle

STARTING A BEAD AND MAINTAINING A GOOD PUDDLE

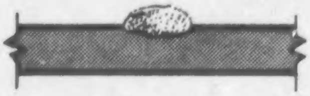

slag
puddle

SLAG FOLLOWING BEHIND PUDDLE

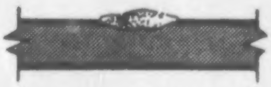
THREE TYPES OF BEADS



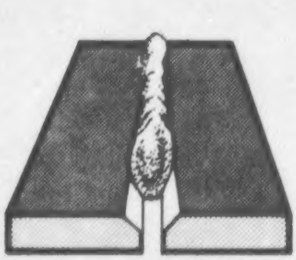
NARROW THIN BEAD



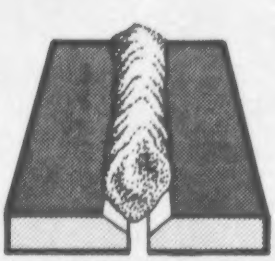
WIDE PILED-UP BEAD



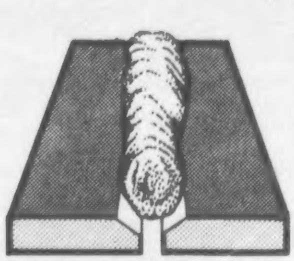
FLAT IRREGULAR BEAD



MOVING FAST

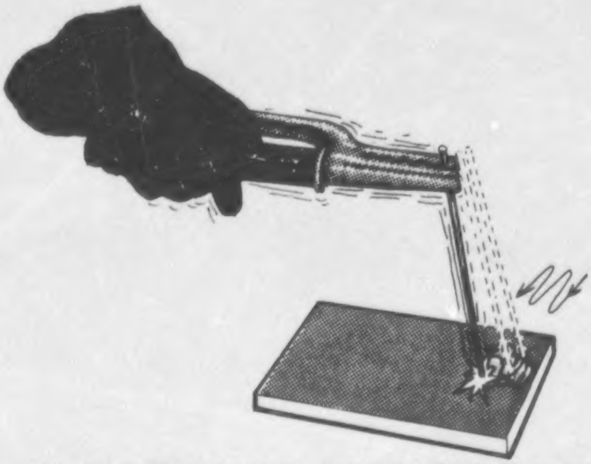


MOVING SLOW



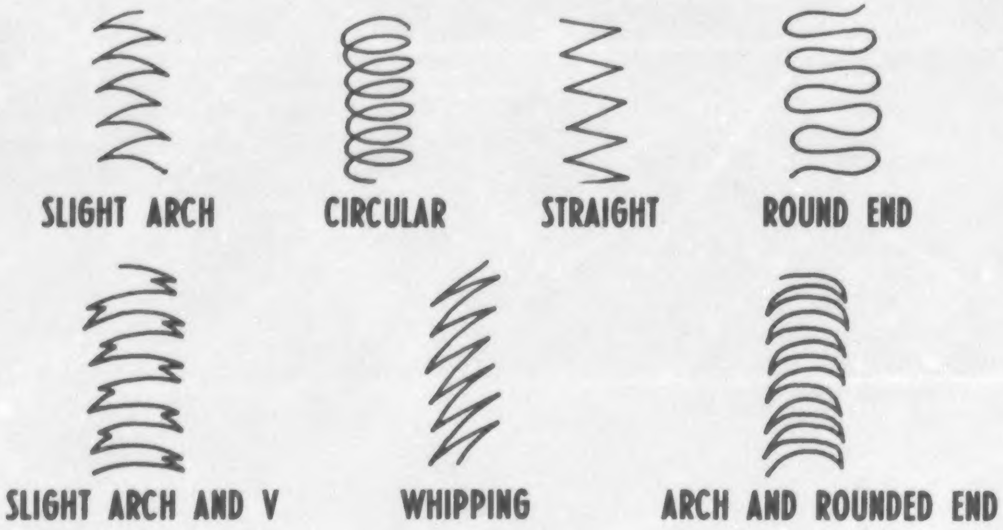
USING LONG ARC

STEPS IN RUNNING A BEAD



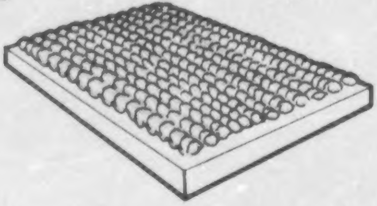
ELECTRODE MOVEMENT

TYPES OF WEAVING

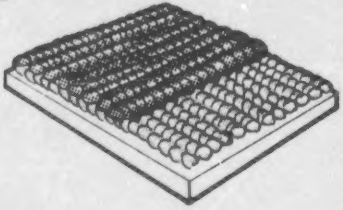

SLIGHT ARCH
CIRCULAR
STRAIGHT
ROUND END
SLIGHT ARCH AND V
WHIPPING
ARCH AND ROUNDED END

PADDING AND WEAVING

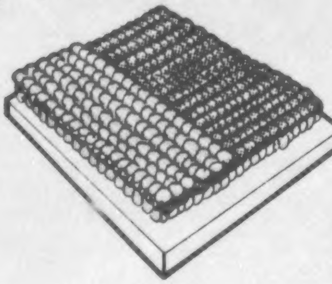
1 FIRST LAYER



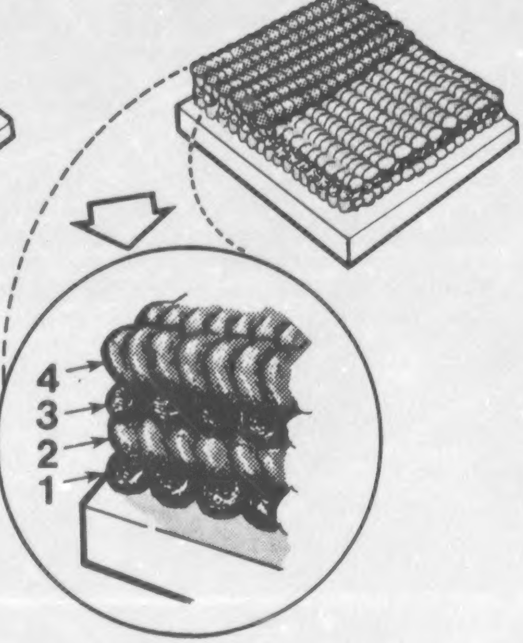
2 SECOND LAYER



3 THIRD LAYER



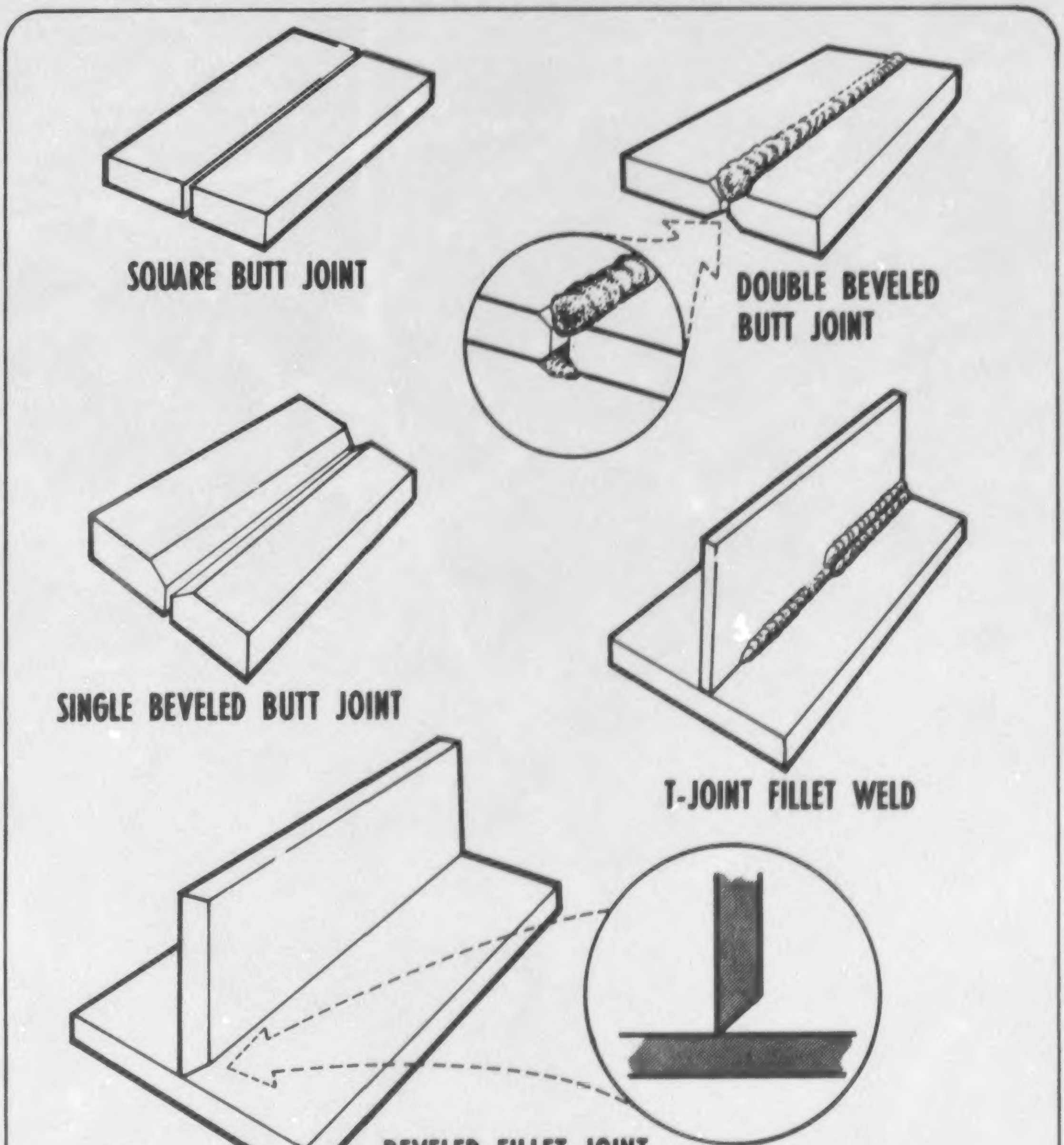
4 FOURTH LAYER



EACH LAYER
IS COVERED

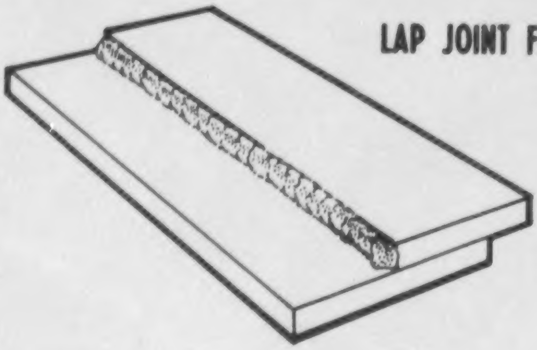
COMPLETE PAD HAS FOUR LAYERS

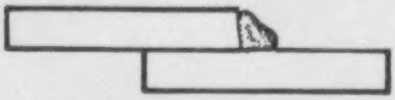
TYPES OF WELDS AND JOINTS


SQUARE BUTT JOINT
DOUBLE BEVELED BUTT JOINT
SINGLE BEVELED BUTT JOINT
T-JOINT FILLET WELD
BEVELED FILLET JOINT

TYPES OF WELDS AND JOINTS

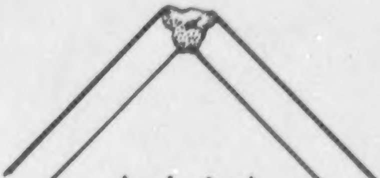
LAP JOINT FILLET WELD



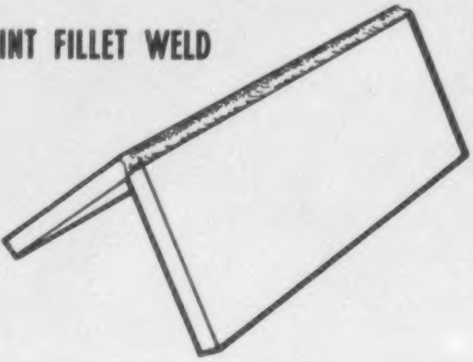


(end view)

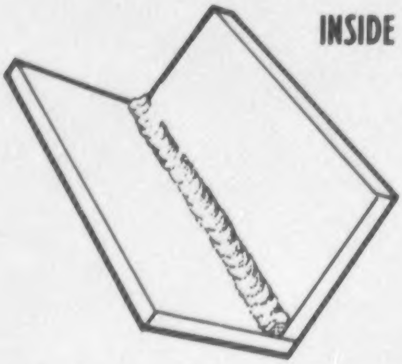
CORNER JOINT FILLET WELD

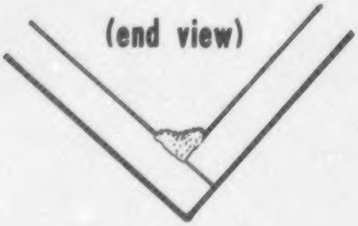


(end view)



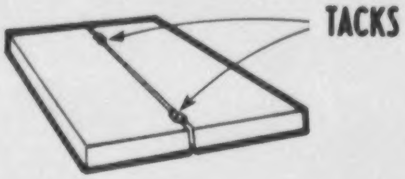
INSIDE FLAT FILLET WELD



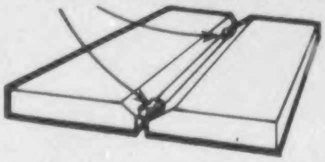


(end view)

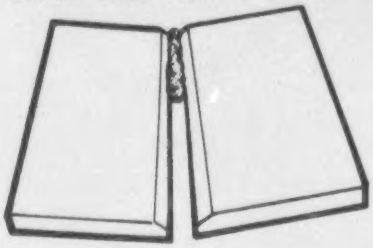
STEPS IN MAKING BUTT WELDS

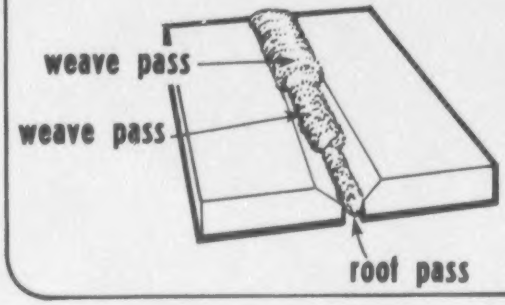


TACKS ON BEVELED METAL

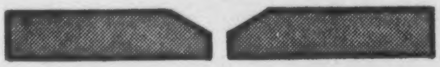


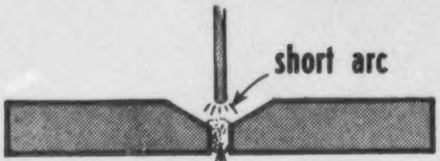
NO TACKS USED (metal moves apart)



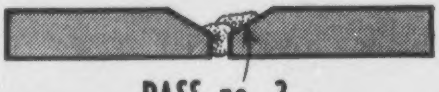

weave pass
weave pass
root pass

BUTT WELD PLATES

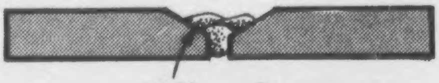




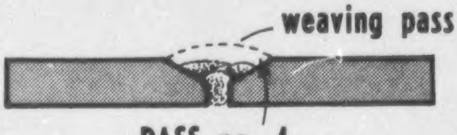
PASS no.1



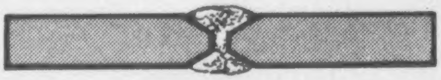
PASS no. 2



PASS no.3

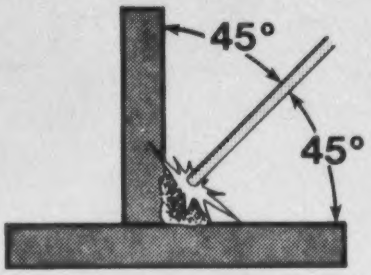

weaving pass

PASS no. 4

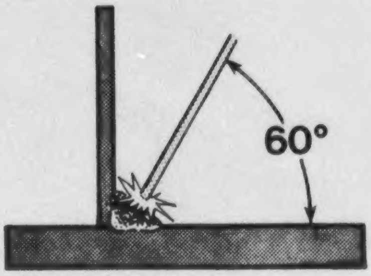


DOUBLE BEVELED
(pass on both sides)

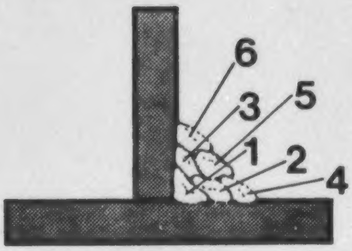
STEPS IN MAKING FILLET WELDS



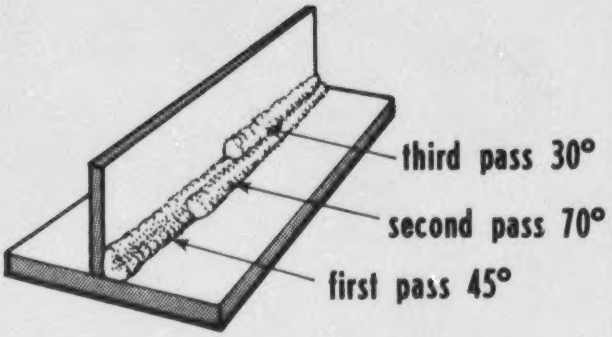
METAL WELDED FORMING "T"



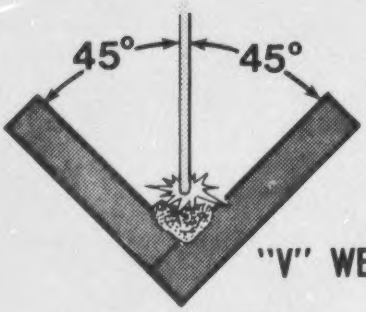
THIN METAL WELDED TO THICK METAL

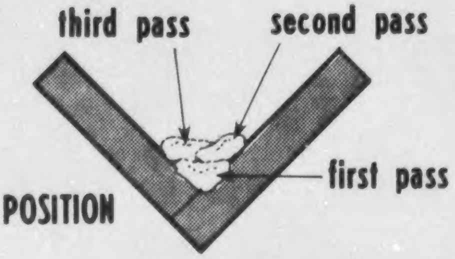


SIX PASS WELD


third pass 30°
second pass 70°
first pass 45°

POSITION OF ELECTRODE

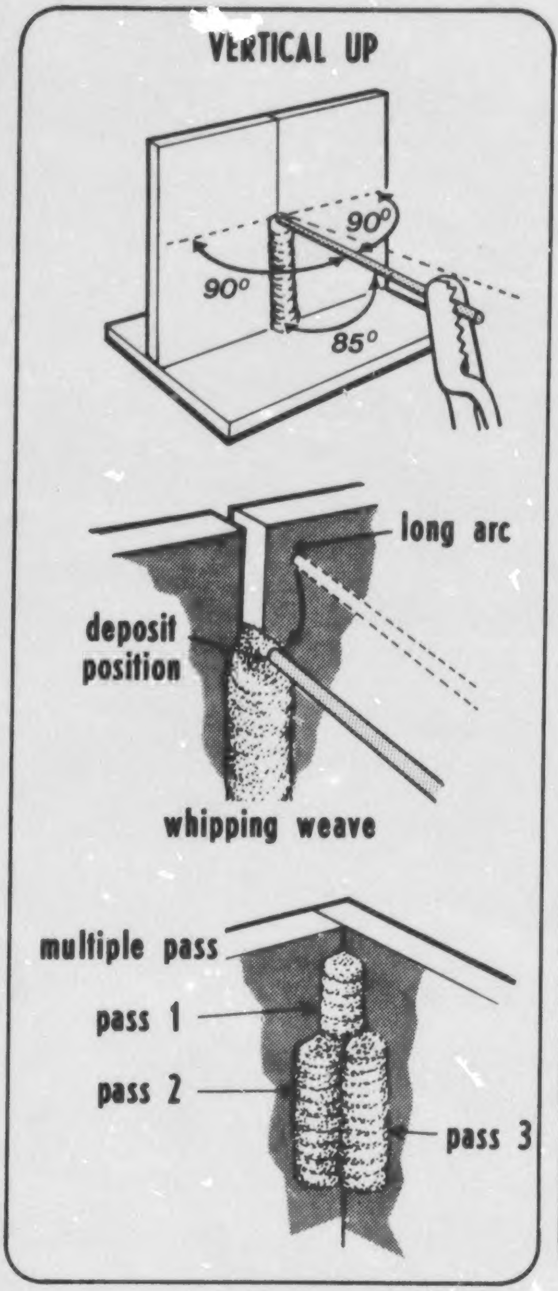


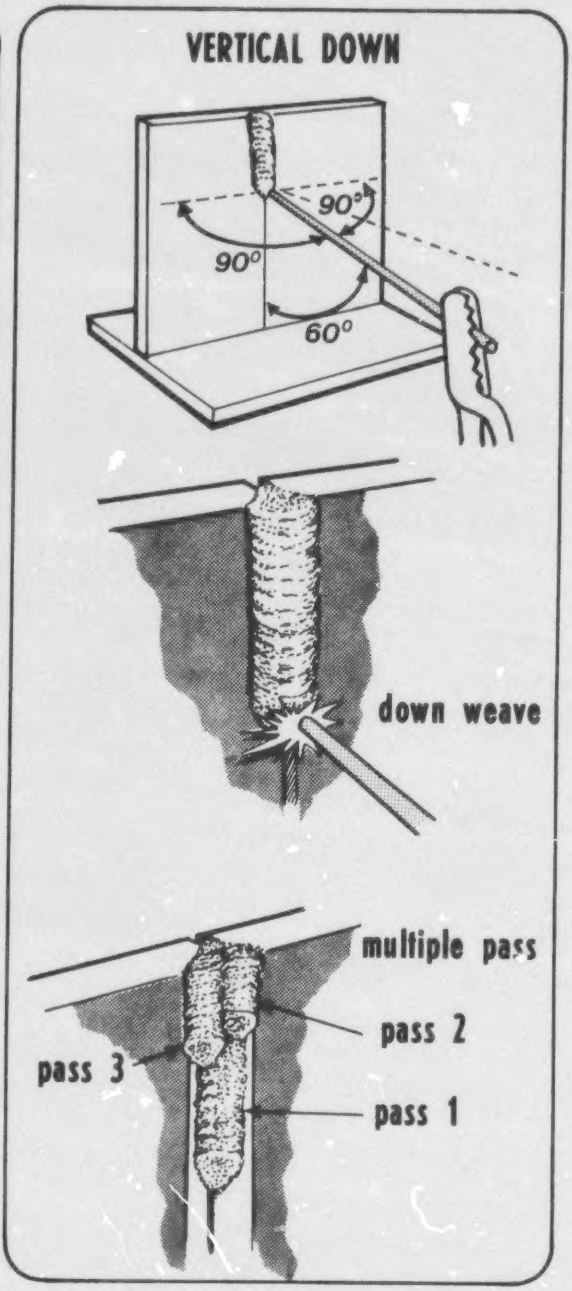

third pass
second pass
first pass

"V" WELD POSITION

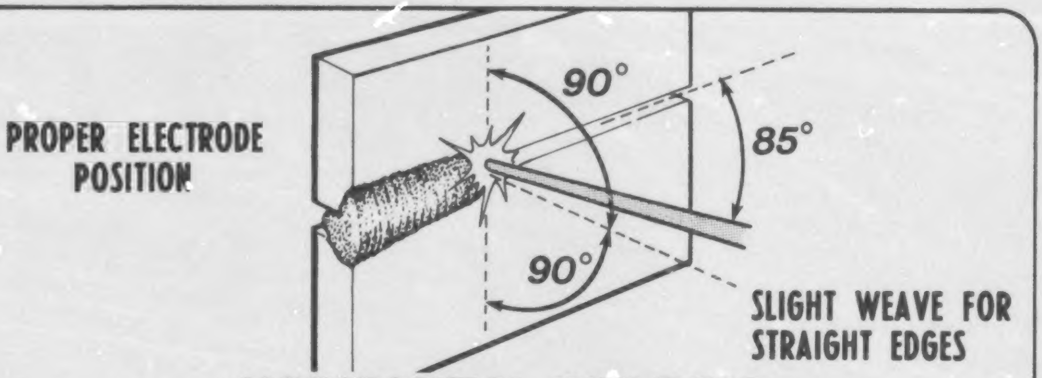
first pass 45°

OTHER WELDING POSITIONS

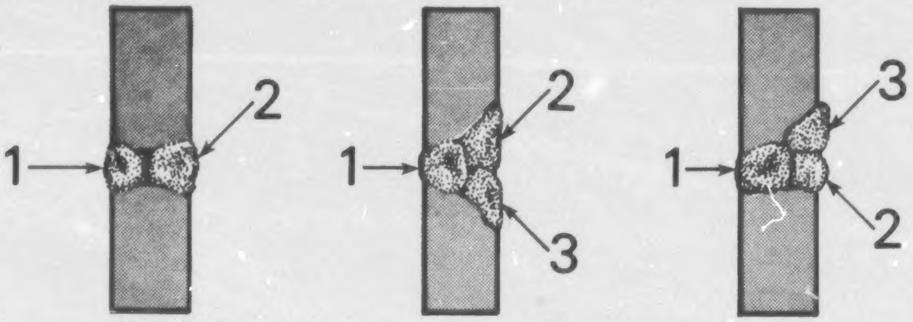

VERTICAL UP
90°
90°
85°
long arc
deposit position
whipping weave
multiple pass
pass 1
pass 2
pass 3


VERTICAL DOWN
90°
90°
60°
down weave
multiple pass
pass 2
pass 3
pass 1

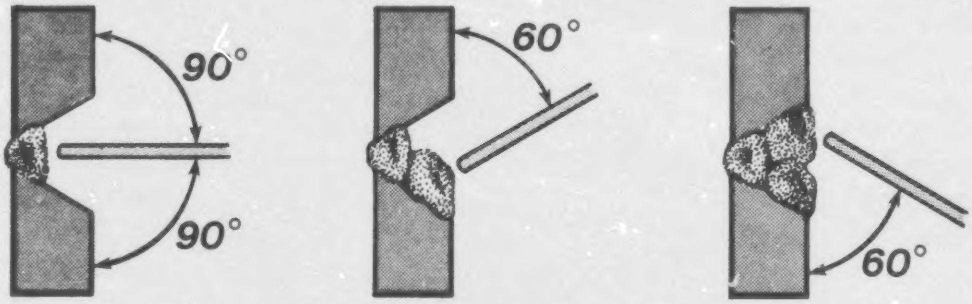
OTHER WELDING POSITIONS


PROPER ELECTRODE POSITION
90°
85°
90°
SLIGHT WEAVE FOR STRAIGHT EDGES

HORIZONTAL WELDING

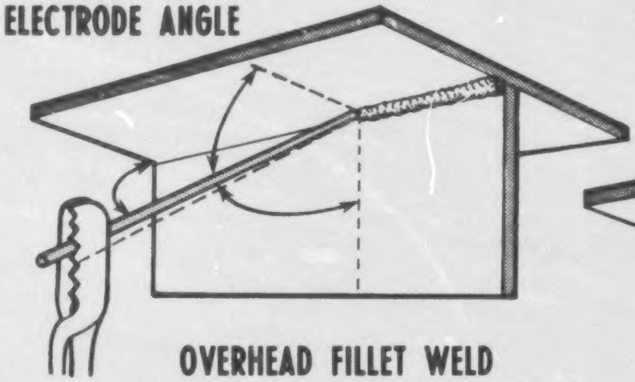


PASSES FOR WELDING HORIZONTAL BUTT JOINTS

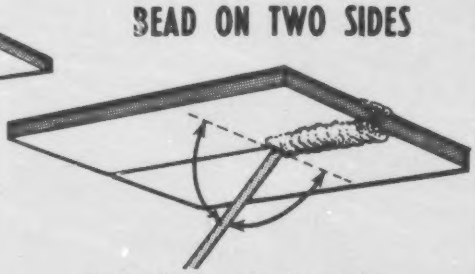


PROPER ELECTRODE POSITION - MULTIPLE WELDS

OTHER WELDING POSITIONS

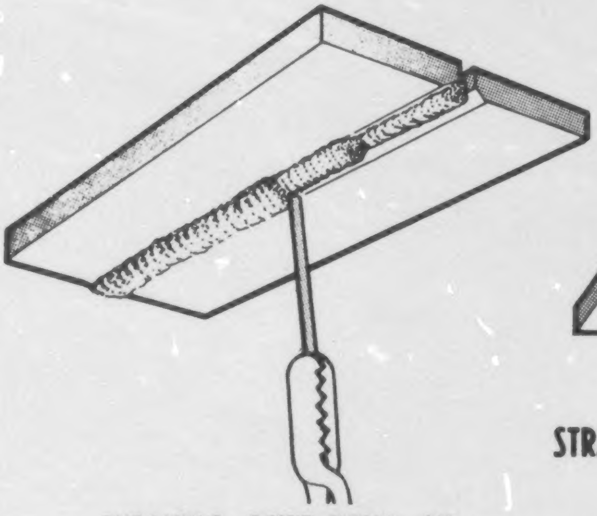

ELECTRODE ANGLE

OVERHEAD FILLET WELD

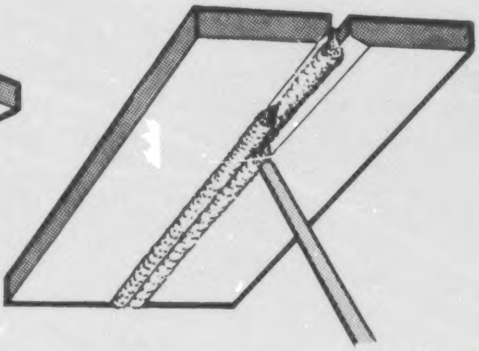

BEAD ON TWO SIDES

OVERHEAD BUTT WELD

OVERHEAD WELDING

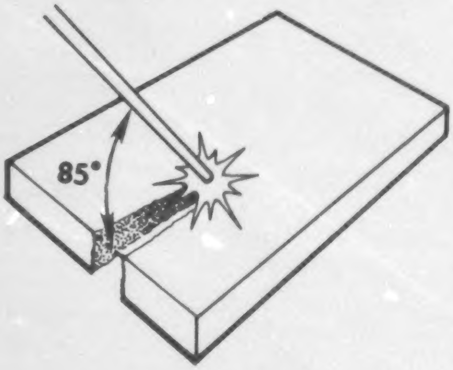


WEAVING BUTT WELD ON
SECOND AND THIRD PASSES

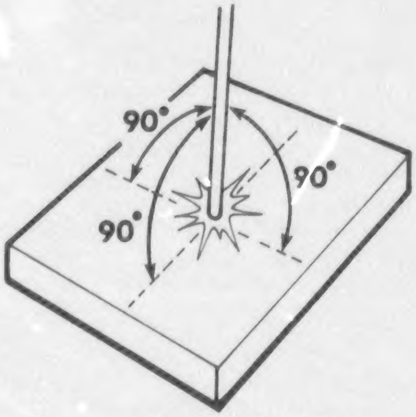


STRAIGHT BEADS FUSED TOGETHER

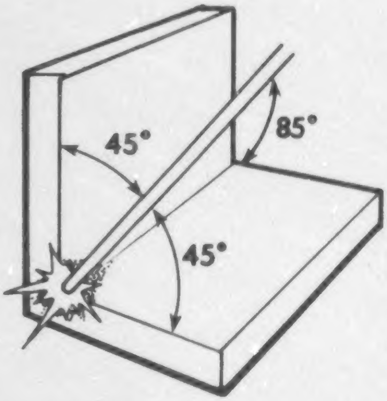
OTHER USES OF ARC WELDER



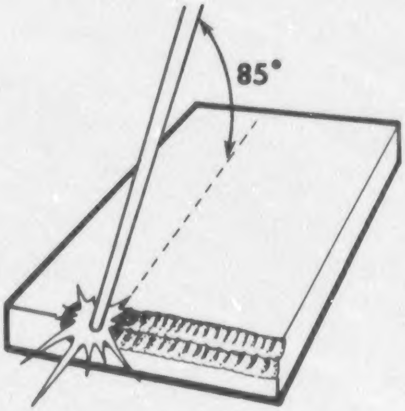
CUTTING



PIERCING

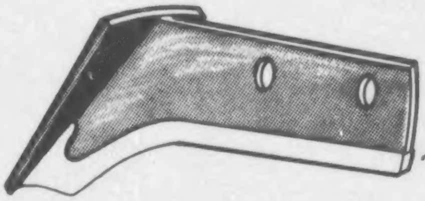


GOUGING

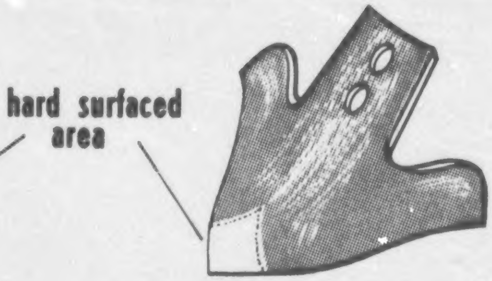


BEVELING

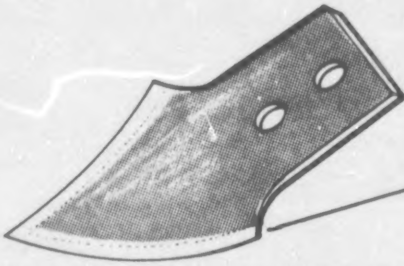
HARD SURFACING



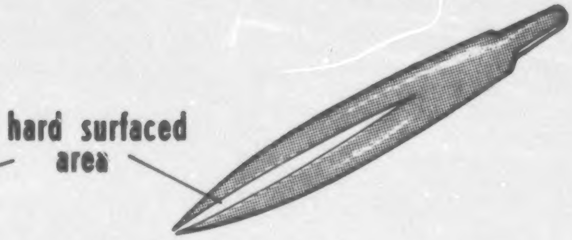
PLOWSHARE


hard surfaced area

SWEEP

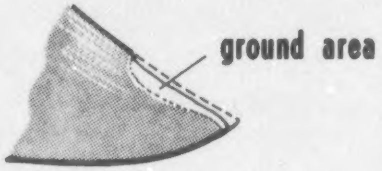


PLANTER SHOVEL

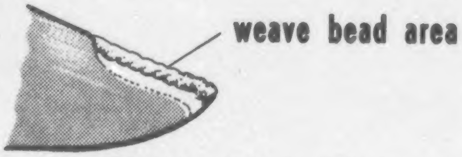

hard surfaced area

HARROW SPIKE

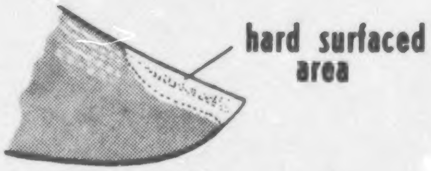
REPAIR OF POINT


ground area

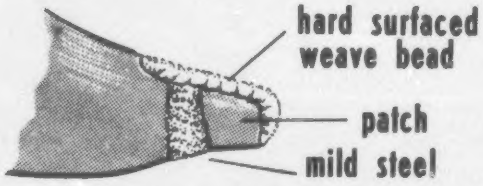
GROUND POINT


weave bead area

HARD SURFACE LAYERED POINT

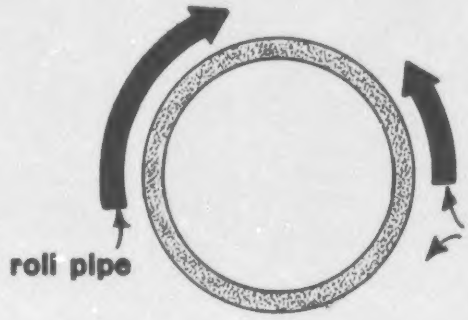

hard surfaced area

FINISHED POINT

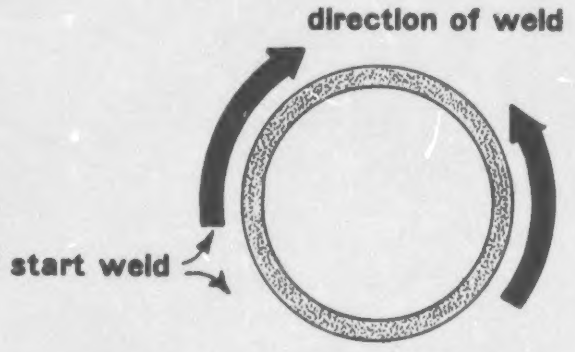

hard surfaced weave bead
patch
mild steel

REPAIR OF BROKEN POINT

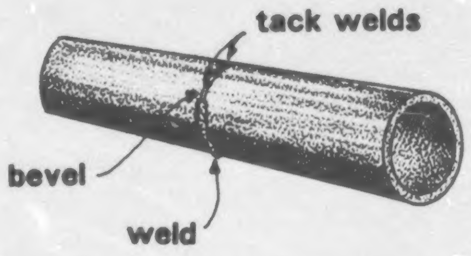
WELDING PIPE

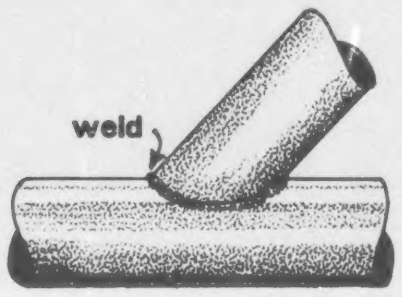


ROLL METHOD

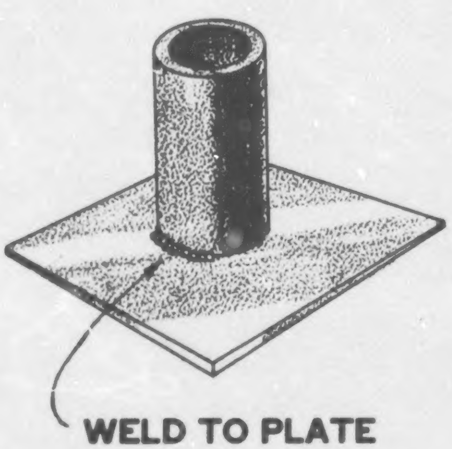

direction of weld
start weld

FIXED POSITION METHOD

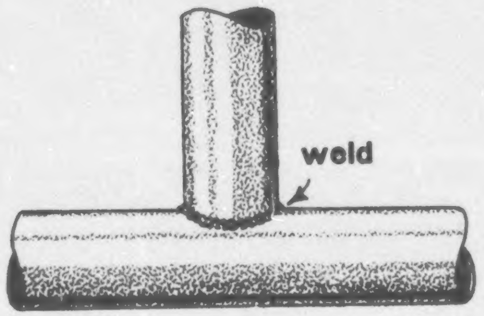

tack welds
bevel
weld



WELD ON 45° PIPE CUT



WELD TO PLATE



TEE WELD

GENERAL AGRICULTURAL MECHANICS

Unit L: Operating Welding Equipment

Topic 2: Gas Arc Welding

Suggested Procedures and Activities: A torch may be displayed and used as a teaching aid during the class discussion.

1. Introduction

The quality of a weld is affected by certain gases, metal oxides, dust, dirt, and other contaminants. Fluxes, gases, and shielding gases are used to improve the chemical and physical qualities of a weld by keeping away air and other contaminants.

The operating principle of gas arc welding is to prevent oxygen and other contaminating material from mixing or entering the molten metal. The torch of a welding unit is designed to provide carbon dioxide, helium, or argon as shielding gases around the electrode. The gas actually keeps atmospheric air away from the weld puddle, arc, and electrode. There are also other advantages of using gas arc welding. They are: welds are cleaner, welds can be made faster, and metals can be welded that cannot be welded easily by other welding methods.

Transparency No. 1

2. Types of Gas Arc Welding

a. Gas Tungsten Arc Welding (TIG)

TIG welding units consist of an electric power unit; pressure reducing regulator; torch or electrode holder containing tungsten electrode, nozzle, and gas passages; torch cable; welding cable; water and gas hoses; and gas supply unit. The TIG process is either helium or argon. Gas is measured and purchased by the cubic foot.

(1) Advantages of a TIG welding unit are:

(a) Welds are free of corrosive residue. This is due mainly to no flux being used. There is no contamination of oxygen and nitrogen due to the inert gas keeping air away.

(b) The weld is usually stronger and freer of corrosion than in other forms of welding. The inert gas will not combine with elements that cause the metal to be impure.
(c) The weld is free of fumes and slag. This makes it easy to observe the process while welding in any position.
(d) Stresses are reduced due to the heat concentration in a small area, so there is little distortion near the weld.
(e) There is no splatter in this process, which means that no metal is transferred across the arc.
(f) Almost all metals and alloys can be welded by this process. Aluminum, magnesium alloys, stainless steel, copper, plain carbon steel, nickel, and hardfacing alloys welded to steel are all welded by the TIG process.

(2) The nonconsumable tungsten electrode forms the arc to fuse the base metal with or without the use of a filler rod. TIG welding units can be either AC or DC powered. This type of arc welding is used extensively to weld aluminum and stainless steel.

b. Gas Metal Arc Welding (MIG)

These types of welders are different from TIG units in that a consumable electrode is used. The electrode is in the form of a thin wire which is usually fed through the torch automatically. MIG units are made up of a welding machine, wire drive and wheel, gas supply, contractor, gun, hoses, current cable (wire), and control unit for wire drive, current, gas flow, and cooling water in part of the unit.

The different types of welding processes make it possible to weld almost all kinds of metal with a MIG unit. The kinds of arc welding are: spray arc welding where metal is transferred from a non-flux wire across the arc; drip transfer welding where metal transfers from the non-flux wire in large drops across the arc; magnetized flux arc welding where the flux adheres to the wire electrode; and flux cored wire electrode where the flux fills the core of the wire.

(1) Advantages of using a MIG welding unit are:

(a) The MIG welder is used in industry as an automatic welder (gun is placed in a variable speed carriage).
(b) Welds can be made by using an electrode with a flux core in the gun.
(c) Other MIG welding advantages are listed under the advantages of the TIG welding unit. However, there is a slag cover on the weld when using a flux cored wire.

(2) MIG welders may be operated by hand. This operation is a semi-automatic system of welding.

c. Other types of gas arc welding processes include gas carbon arc welding (CIG) and gas arc spot welding (GASW). The most commonly used type of arc welding is still the use of a coated electrode (stick electrode) that shields the metal puddle from atmospheric air. Burning chemical compounds from the coat on the electrode form a blanket of smoke and gas around and over the molten pool of metal.

3. Safety Precautions

The safety precautions to observe when gas arc welding are:

a. Protect the eyes by using dark shade lens, #12 to #14. The exposed intense arc will damage the skin and eyes.

b. Keep the machine in good condition by repairing water leaks that appear if the machine is the water type. Electrical shock may be caused by wet equipment or wet floors.

c. Never work on the equipment without first disconnecting both the primary and high-frequency circuit equipment.

d. Check the area for good ventilation. Carbon monoxide, carbon dioxide, oxides of nitrogen, and decomposed (trichloromethylene) gases can be minimized by proper ventilation. A small amount of oxygen is changed into ozone during the welding process. Ultraviolet rays are about two times as strong as the flux shielded arc rays. A #2 set of flash goggles, side shields, and a #12 lens in the helmet are recommended for eye and face protection.

e. Wear the proper clothing to protect the skin. Light cotton clothes are not recommended. Leather or wool clothing makes a more desirable protective cover.

Transparency No. 2

4. Gas Tungsten Arc Welding (TIG)

a. Starting the Unit - Check to see if the gas and water are on (water cooled unit). The control may be in the torch hanger or electrode holder. In some units the flow is controlled automatically. Water flow may vary from 12 to 23 gallons per hour in a water colled unit. The gas flow (cu. ft./hr.) is determined by the kind and thickness of metal being welded.

b. Electrodes - Tungsten electrodes are of three shapes. The AC electrode has a spherical end, the DC straight polarity (DCSP) a pointed end, and the DC reverse polarity (DCRP) a round or ball end.

c. Striking the Arc - The following method is used for striking an arc:

(1) When using high frequency alternating current, move the torch to the horizontal position over the work or block. Direct the torch to the upright position and the electrode within 1/8 inch of the work. The arc should jump this gap.

(2) If direct current is used, the electrode must touch the work and be withdrawn to the proper distance for welding. To keep the tungsten electrode clean, touch it to a tungsten block.

(3) In order to warm the tungsten torch and make the starting of a weld easy, use a practice piece of metal before starting the actual weld.

(4) Before starting a weld check the electrode extension so that it will extend out of the nozzle a distance equal to the inside diameter of the nozzle except when fillet welding, in which case the electrode should be longer.

d. Special Welding Instructions - Steel alloys should be at a temperature of 60 degrees F. or more and aluminum 120 degrees F. before welding. Steel cools to about 350 degrees F. and aluminum to 300 degrees F. between welding passes. To protect the penetration side of the weld, four or five spurts of gas should be used; then continue feeding the gas at a steady rate while welding. If cracks appear at the beginning of the weld, remove them by buffing or grinding on the emery and reweld. This condition may also happen at the end of a weld. When welding pipe smaller than 6 inches in diameter the passes are about 2 inches long, and for pipe over 6 inches in diameter, passes can be 3 inches long. Tungsten electrode for AC welding can be cut by first nicking the electrode with a grinding wheel and then breaking with pliers.

e. Making a Weld - Use the following procedure when welding with the tungsten arc welder:

(1) Prepare 60-degree grooves for joints if the metal is thicker than 3/32 inches thick. Welds can be made with no edge preparation. Special precautions should be used to keep out air impurities when

welding magnesium and titanium joints. Flange joints should be used by the beginner. The kind of metal being welded determines the type of filler electrode to be used and the type of current needed.

(2) When starting the weld make a small beginning puddle and hold the electrode holder between 60 and 80 degrees to the metal. Use a very small circular motion for starting the puddle.

(3) Move the arc back of the puddle and place the filler rod inside the front part of the puddle; that is, if a filler rod is used. The filler rod should be held almost flat (about 20 degrees) as it is moved in front of the weld.

(4) The weld can usually be stopped in two different ways: by reducing the current with the foot control or lifting the electrode holder to break the arc. The gas should be kept flowing until the tungsten electrode has cooled.

(5) Make horizontal and overhead welds using the procedure as in regular arc welding. When welding in the vertical position, weld downward.

(6) Always use the proper size and type of electrode for the job. If the electrode is entirely too small it may melt back to the collet (inside holder). A large electrode may cause the arc to wander from side to side.

(7) Weld all metals immediately after cleaning. Dirty metal will cause contamination of the electrode and weld.

Transparency No. 2

5. Gas Metal Arc Welding (MIG)

a. Starting the Unit - Turn on the ventilating system, water valve, gas system, and correct welder for wire size. Check electrode feed speed without making an arc. With diagonal pliers cut the electrode 1/2 to 3/4 inch in length. Touch metal with electrode before lowering helmet and pressing starter button on torch handle.

b. Do the welding in any position that it is done with the regular arc welder or tungsten gas welder. Vertical welding is usually accomplished in the same manner as regular arc welding, the movement being from bottom to top.

c. Metal is prepared for MIG welding in the same way as preparing for regular arc welding; that is, V-groove or weld square butt joints. As in TIG welding, the metal must be clean. Also, as in TIG welding, the MIG wire (electrode) size and current setting must be correct for the type of weld being made. However, the wire feed speed may be another factor to consider when doing this type of welding. When changing to a larger diameter wire (electrode), either the current must be increased or the speed of travel reduced. An example of speed is as follows. When welding approximately 26 inches per minute:

Mild steel - .060 thickness
DC amps - 130
Argon flow - 17 cu. ft. per hour

References:

1. Althouse, Andrew D., and Others, Modern Welding, The Goodheart-Willcox Company, Inc., South Holland, Illinois, 1976

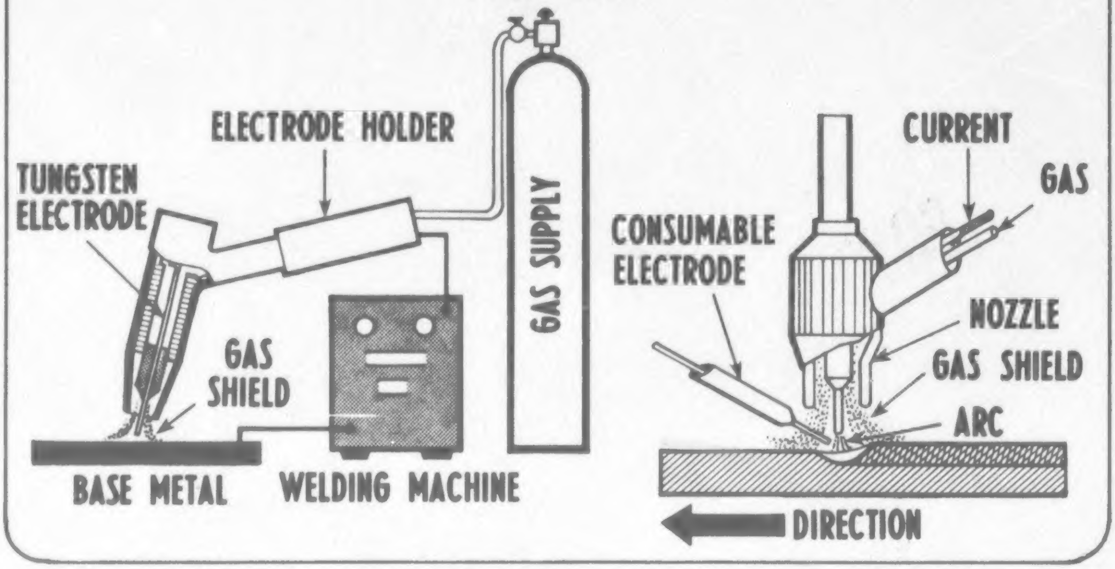
2. Griffin, Ivan H., and Edward M. Roden, Welding Processes, Delmar Publishers, Albany, New York, 1970

3. Phipps, Lloyd J., Mechanics in Agriculture, The Interstate Printers and Publishers, Inc., Danville, Illinois, 1967

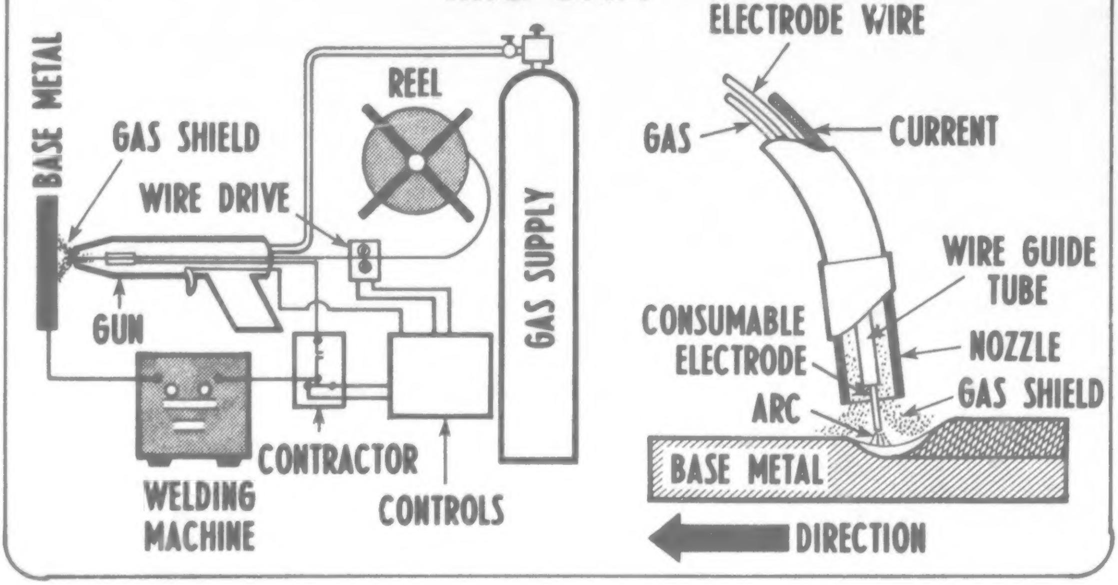
4. "Shielded Metal-Arc Welding", Vocational Agriculture Service, Urbana, Illinois, 1972

TIG AND MIG WELDING UNITS

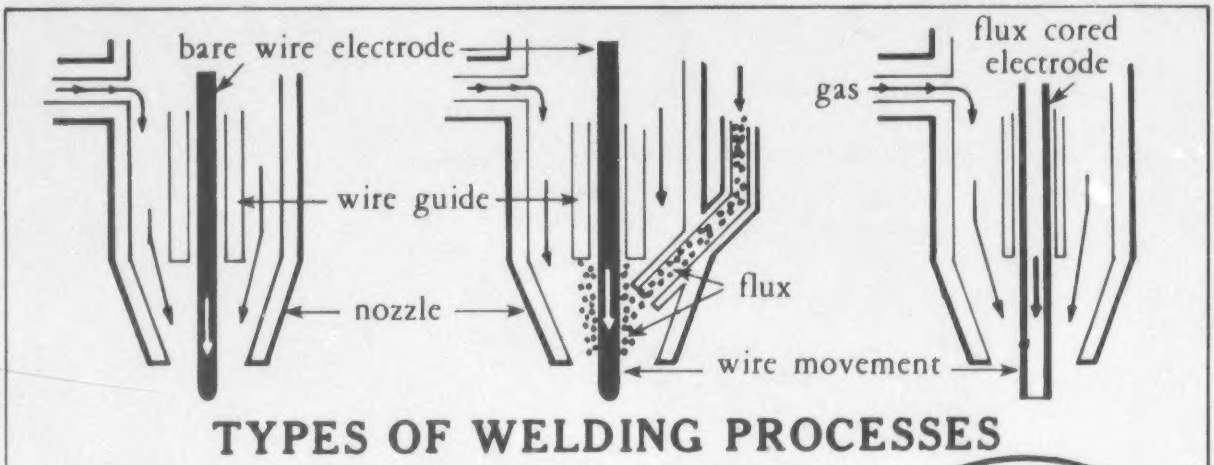
TIG UNIT


ELECTRODE HOLDER
TUNGSTEN ELECTRODE
GAS SHIELD
BASE METAL
WELDING MACHINE
GAS SUPPLY
CURRENT
GAS
CONSUMABLE ELECTRODE
NOZZLE
GAS SHIELD
ARC
DIRECTION

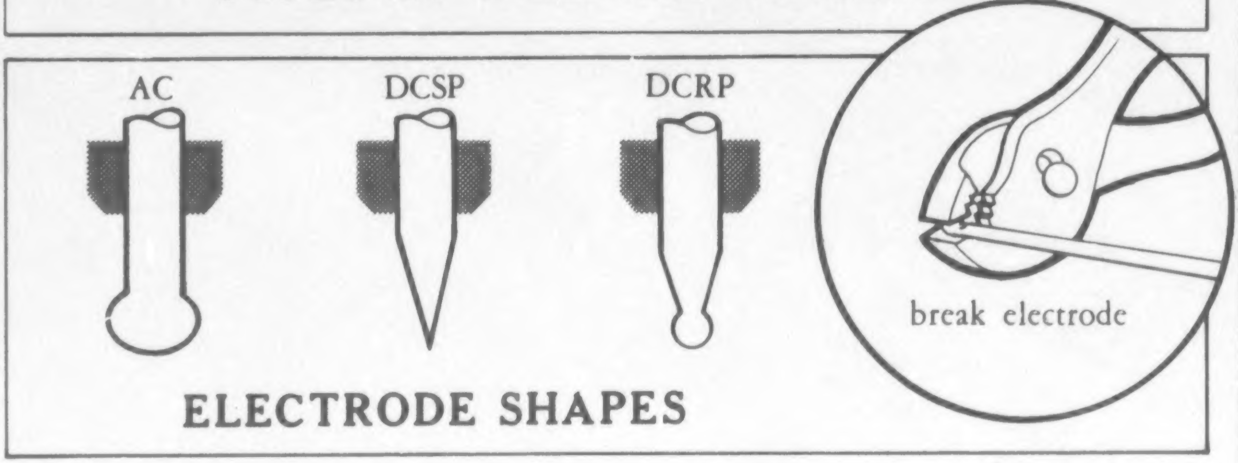
MIG UNIT


BASE METAL
GAS SHIELD
WIRE DRIVE
REEL
GUN
GAS SUPPLY
CONTRACTOR
WELDING MACHINE
CONTROLS
ELECTRODE WIRE
GAS
CURRENT
WIRE GUIDE TUBE
CONSUMABLE ELECTRODE
NOZZLE
ARC
GAS SHIELD
BASE METAL
DIRECTION

GAS ARC WELDING

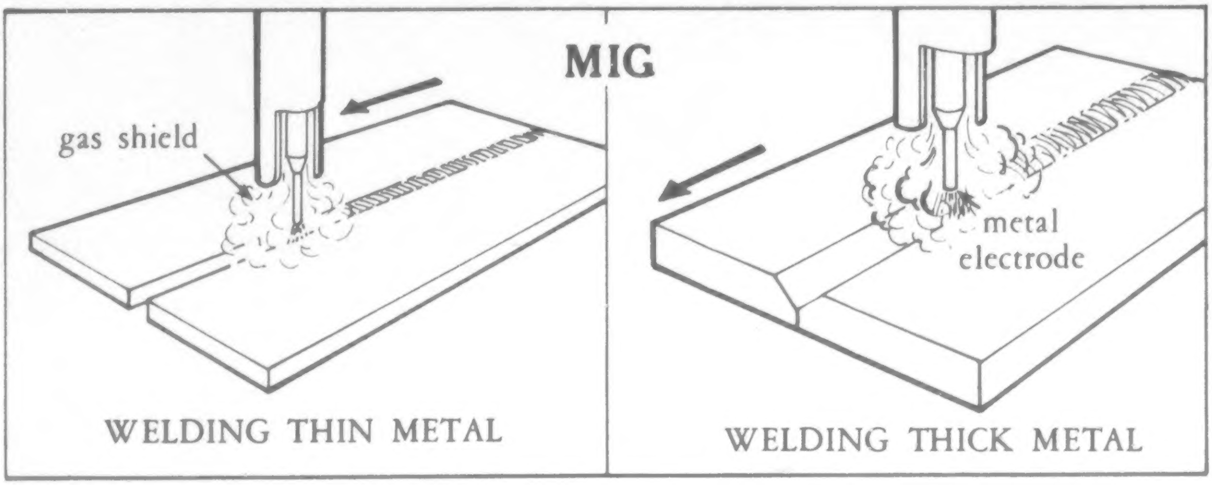

bare wire electrode
flux cored electrode
gas
wire guide
flux
nozzle
wire movement

TYPES OF WELDING PROCESSES


AC
DCSP
DCRP
break electrode

ELECTRODE SHAPES

MIG


gas shield
metal electrode

WELDING THIN METAL

WELDING THICK METAL

GENERAL AGRICULTURAL MECHANICS

Unit L: Operating Welding Equipment

Topic 3: Oxyacetylene Cutting and Welding

Suggested Procedures and Activities: If the oxyacetylene unit is mobile, move it into the classroom and use it as a teaching aid during the class discussion. If the unit is immobile, such equipment as cutting and welding tips, spark-lighter, cutting attachment, welding torch, and goggles could be used as teaching aids.

1. Definition of Oxyacetylene Cutting and Welding and Its Importance for Farm and Ranch Use

Oxyacetylene cutting is a process used to separate metal by heating it to a kindling temperature (burning temperature) between 1,400 and 1,800 degrees F., then oxidizing and blowing the metal from the cut with a stream of oxygen.

Oxyacetylene welding is the joining of two pieces of metal together by heating them to the melting point provided by combustion of a gas mixture, oxygen and acetylene.

The oxyacetylene flame is used to weld iron, steel, brass, copper, aluminum, bronze, cast iron, and special alloys. It is also used extensively for cutting metal, annealing, and hardening.

The flame reaches a temperature of about 6300 degrees fahrenheit. The temperature may be adjusted to fuse or cut (melt) any commercial metal.

An oxyacetylene welding and cutting outfit is considered a very useful tool for the modern farm and ranch. It is used to build equipment and do repair jobs. When repairing equipment, oxyacetylene flame may be used to heat metal for bending, forming, straightening, hardening, tempering, and removing paint and rust on equipment.

Oxyacetylene cylinders may be purchased in light-weight sizes for easy handling or moving from place to place on the farm. Usually, it is more economical for a farmer to purchase cylinders due to the demurrage charge if they are used more than one month.

2. The Major Functions of Oxyacetylene Heat Are:

a. Metal is joined by the fusion process. The heated (melted) portions fuse together forming a weld. The process can be accomplished with or without the use of a welding rod.

b. The joining of metals or metal by adding bronze as a filler is known as brazing. Base metal is heated to a temperature that will cause the bronze to stick and bond the metals together.

c. Soft and hard solders (lead and silver alloys) are the filler materials in soldering. The base material is heated to a temperature that will cause the solder to stick.

d. Oxyacetylene flame is used to bend, shape, preheat, postheat, and temper metals. Heating of metals is one of the most important functions of the oxyacetylene flame.

e. The oxyacetylene flame is also important in separating metals. The metal oxidizes after a kindling temperature is attained and pure oxygen is applied to it. This practice is known as cutting or burning.

3. Description of Oxygen and Acetylene

a. Oxygen (O_2) is one of our most abundant gases. One-fifth of the air breathed is oxygen. It is colorless, odorless, and tasteless and is heavier than air. Oxygen is considered a supporter of combustion. It is produced commercially by causing air to liquify and using fractional distillation to recover the oxygen.

b. Acetylene (C_2H_2) has a distinct odor and like oxygen is colorless. When calcium carbide and water are mixed a hydrocarbon is formed. The equation is $CaC_2 + 2H_2O = C_2H_2 + Ca(OH)_2$ acetylene and calcium hydroxide. Acetylene burns in both the primary combustion area (cone of the flame) and the secondary combustion area (envelope of the flame). The end of the inner cone may produce a neutral flame temperature from about 5,400 to 6,300 degrees F. The temperature is raised by adding oxygen.

4. Oxyacetylene Safety Practices

Transparency No. 1

Safety cannot be "Bought"; it must be "Practiced", this is especially true when working with oxygen and acetylene gases. The most common hazards found in welding are burns caused by heated metal and welding dust, and injuries due to toxic gases or fumes. The weldor should be thoroughly informed regarding all safety practices, including the use of oxygen and acetylene for both welding and cutting.

a. Personal safety rules to observe are:

(1) Be neat and clean about work and work areas. Keep equipment clean and in good operating condition.

(2) Never use oxygen as air pressure for cleaning or in pneumatic tools. Oxygen must not be used in oil preheating burners, to blow out lines, to create pressure in containers, or any place as a substitute for compressed air or other gases.

(3) Use a friction lighter or pilot lighter to light torches - Never Use Matches to Light a Welding Torch!

(4) Protect the eyes by wearing goggles or head shield with suitable lenses when using a torch.

(5) Wear leather gloves, protective shoes, and clothing that is completely free of oil with pockets and cuffs protected from sparks or hot metal. Do not hang articles of clothing on cylinders, because clothing may become saturated with acetylene and explode or ignite.

(6) Ventilate working areas. Do not use oxygen for ventilation. Make sure that oxygen concentrations above normal cannot be developed in the work area. Leave gas cylinders outside when working in small enclosures.

(7) Always refer to acetylene as "Acetylene" - not "Gas". Refer to "Oxygen" as oxygen - not "Air". The word gas is a general term and confusion here is dangerous. The use of the term "Air" instead of the word "Oxygen" may lead to a serious accident.

b. Safety rules to observe when handling cylinders include:

(1) Keep oil and grease away from cylinders and never use these types of lubricants on the valves or connections.

(2) Use cylinders in rotation as they come from the supplier. Mark the empty cylinders and send marked cylinders back to the supplier promptly. Also, keep "empties" and "fulls" separate to avoid serious results. Keep the valves closed on "empties".

(3) Keep cylinders away from exposures to sparks, hot slag, open flame, and all possible sources of excessive heat.

(4) Always secure cylinders in an upright position to a suitable support. Letting a cylinder fall can be dangerous. Also, transport and store cylinders in an upright position. Do not attempt to lift cylinders with make-shift equipment. The most popular cylinder mount is a cylinder cart.

(5) Never use cylinders as a ground or a source of an electric circuit. Do not strike an arc on a cylinder with the electric arc unit and do not hit the cylinder with any object, especially if the object is metal.

(6) If cylinder valves cannot be opened by hand, never use a hammer or wrench; notify the supplier and if leaks appear, move cylinders out of shop area and also notify supplier.

c. Safety practices to observe when attaching and using the welding unit apparatus are as follows:

(1) Keep all apparatus clean and free from oil. Do not use oil on the regulators - oil and oxygen can cause a dangerous explosion.

(2) Open the cylinder valves slowly after attaching the regulators, allowing the hand on the cylinder gauge to move slowly on the dial away from the pin. A full oxygen tank contains about 2000 psi (pounds per square inch) and a full acetylene tank 250 psi.

(3) Do not use defective or leaky apparatus - have it repaired. Matches or any type of flame should not be used to test for leaks. The use of soapy water is safe when testing for leaks. Use a paint brush to apply the soapy water on all connections.

(4) Stand to one side of the regulators when making valve and regulator adjustments.

(5) Use wrenches on blowpipes and other connections only as directed by the manufacturer. Most blowpipes are designed for hand tightening.

(6) Use as short a hose length as possible. Remember, the longer the hose, the higher the pressure required. Hose leaks must not be repaired with tape. A leaky hose should be replaced with a new hose. Do not kink the hose, as this practice injures hose linings. Keep sparks and hot metal away from hoses.

(7) Do not attempt to repair torches or regulators unless properly trained.

(8) Never put acetylene under a pressure of more than 15 psi. Acetylene over this pressure is seldom used for welding. This gas is explosive at any pressure if a spark or flame is present in a small closed area.

(9) After finishing a welding job, first turn off the acetylene torch valve and then the oxygen valve. The hose color will identify the two different gases.

(10) Prevent fires by keeping tips clean, using proper pressure, keeping connections tight, properly heating metal, keeping tips firmly seated, and using friction lighter.

(11) Keep fire extinguisher ready to use in case of fire.

d. Some general safety practices to observe include:

(1) Never weld or cut on containers that might have been used to hold flammable materials. Some of the most serious accidents are caused by working on this type of item. The weldor may still be in danger even if the container is filled with water.

(2) Cut and weld when under the supervision of an experienced teacher or weldor. Safety practices are respected by these types of people.

5. Equipment Necessary for Oxyacetylene Cutting and Welding - Setting Up Equipment

Transparency No. 2

a. Equipment

(1) Cylinders - The two types of cylinders are oxygen and acetylene. Both types are made to hold gases in cubic feet measures. The sizes of oxygen cylinders are 244, 122, and 80 cubic feet. Acetylene cylinders are measured in 300, 100, and 60 cubic feet. These cylinders are equipped with a safety device to let the gases drain slowly if heat causes the pressure to rise.

(2) Regulators - Both oxygen and acetylene regulators have two gauges; one

gives the amount of pressure in the cylinder and the other the torch pressure. When using a neutral flame the following pressures readings are used for certain makes of welding tips:

Oxygen Pressure	Acetylene Pressure	Metal Thickness	Size of Tip
2 1/2 lbs.	1 lb.	1/16"	1
7 1/2	3	1/8	3
12 1/2	5	1/4	5
17 1/2	7	1/2	8
18 3/4	7 1/2	5/8	9

(3) Cutting Torch - The cutting torch provides a preheat mixture of oxygen and acetylene for heating the metal and a pure stream of oxygen for blowing the heated metal from the intended cut. The torch is equipped with both oxygen and acetylene valves and a cutting valve lever that controls pure oxygen.

(4) Welding Torch - This torch is also equipped with a gas mixing chamber. The gases are controlled by the two valves located at the back of the torch handle.

(5) Hoses - Special type of non-porous hoses carry the oxygen and acetylene from the regulators to the torch. Oxygen hoses are usually green or black, and acetylene hoses are red in color. Oxygen hoses have right-hand threads and acetylene left-hand.

(6) Cutting and Welding Tips - Cutting tips have four preheat orifices and one cutting oxygen orifice. This orifice is located in the center of the tip. The thickness of metal regulates the size of tips to be used. Welding equipment manufacturers identify tips by both letter and number. Heat and flame from the preheat holes form the inner cone. This cone has a short flame, whereas the cutting oxygen flame is long.

(7) Welding Tips - Different sizes of welding tips, like cutting tips, are interchangeable in the blowpipe. The size is also similar to that of the cutting tip in that it is governed by the orifice. Welding tips only have one orifice. However, the numbering system which regulates sizes (ranging from 00 to 15) depends on the tip manufacturer.

(8) Necessary Miscellaneous Equipment - The friction lighter is the only

safe type of lighting equipment used. It lights both the cutting and welding torch. Open end or adjustable wrenches are used on the regulator and torch connections. Wrenches are usually supplied with a welding unit. In the tip cleaning set, cleaners are made to fit the orifices in both cutting and welding tips. Such items as soapstone for marking, c-clamps for holding stock, and wire brushes for cleaning metal are essential in a welding and cutting outfit.

(9) Weldor's Clothing - The operator should not attempt to cut or weld metal without protective goggles. They protect the eyes against dangerous rays, glare, and sparks. Fire-resistant gloves are recommended for welding to protect the hands against heat radiated by the torch and metal. Clothing should be of the type that protects the body against sparks and heat.

b. Setting up equipment involves the following steps:

(1) Fasten Cylinders - After fastening cylinders either in a portable cart or against the wall, remove the protective caps, and crack valves slightly to clean foreign matter from inside the nozzles, then close the valves.

(2) Connect Regulators - Fasten regulators to respective cylinders and tighten union nuts. Open the regulator adjusting screws by turning counterclockwise until they feel loose, then open the cylinder valves very slowly, allowing the pressure to move the gauge hands (oxygen and acetylene) on the dial very slowly. A T-wrench is used to open the acetylene valve.

(3) Connect Hoses - Attach the red hose to the acetylene regulator and the green or black hose to the oxygen regulator. Note: right-hand threads are on the oxygen hose and left-hand threads on the acetylene hose. It may be necessary to turn the regulator adjusting valves clockwise to blow the hose out. About 5 pounds of oxygen will clean the hoses. If the acetylene hose is cleaned with oxygen, it is attached to the oxygen regulator with a special connection. Assuming the blowpipe needs cleaning, open both blowpipe or torch valves after the torch is connected to the hoses and blow the torch out with about 5 pounds of oxygen pressure.

(4) Select and Insert Cutting or Welding Tip - After the proper size of cutting tip is selected, it should be tightened with a wrench. The welding tip is tightened by hand. Tips are selected according to the thickness of metal. For example, a welding tip 00 is used on thin metal

(1/32 inch or less),whereas a number 14 tip is used to weld thick metal (1 inch and over). The right size tip will let gas flow at the proper rate for fusing metals together.

(5) Turn on Unit - Fully open the oxygen cylinder valve and turn the acetylene 3/4 to one turn open. With the oxygen needle valve open on the torch, adjust the pressure gauge to the desired working pressure, and then close the needle valve. The same procedure is followed for regulating the acetylene.

(6) Test for Leaks - Use soapy water and a paint brush to check for leaks at the following points:

Transparency No. 2

(a) Oxygen and acetylene cylinder valves
(b) Regulator valve inlets
(c) Hose connections at regulators and blowpipe or torch
(d) Area around needle valves
(e) Area around tip connections

6. Oxyacetylene Cutting Parts and Adjustments

Transparency No. 3

a. A different type of torch (blowpipe and tip) is used for cutting metal than is used for welding. The cutting tip has 3 to 8 holes located around the center hole. These small orifices (holes) furnish flames to preheat the metal, and the center orifice furnishes oxygen to cut the metal.

b. An oxyacetylene cutting torch has three controls. They are: preheat oxygen valve, preheat acetylene valve, and a cutting oxygen valve that is controlled by a lever. The two preheat valves actually furnish heat on the surface to a kindling temperature of the steel being cut and the cutting oxygen controlled by the lever ignites the molten metal and blows it from the heated area.

c. Lighting and adjusting the blowpipe are very important steps when cutting metal. If the manufacturer's instructions are not available, the following procedure may be used:

(1) Hold the blowpipe with the tip pointing away from the body. Open the acetylene valve about 1/2 turn and light the torch with the friction lighter. The flame should clear the tip end about 1/8 inch when first lit, but it should be adjusted back to the tip.

(2) Adjust the regulator pressure by turning the adjusting screws clockwise. Oxygen pressure depends on the thickness of metal being cut, usually 15 or more pounds per square inch. For example, 1-inch thick metal requires about 30 psi. Acetylene pressure varies from 3 to 5 psi and never exceeds 15 psi.

(3) Adjust the preheat oxygen valve until a neutral flame appears with sharp inner cones, then press the cutting oxygen lever and readjust the flame by turning the preheat oxygen valve while the cutting lever is in the downward position. This readjustment is to correct the flame from carburizing to neutral when raising the lever.

7. Cutting Metals

Transparencies Nos. 3, 4, and 5

a. The metal to be cut should be clean, marked with a punch or soapstone, and placed in a suitable position for cutting. The position can also involve the location for cutting. For example, moisture in a concrete floor will cause small pits where the hot metal falls. This can be prevented by using a container to catch the molten metal. Hot metal will also damage welding unit hoses and may even cause fires.

b. Cutting metals by using the oxyacetylene process is more or less limited to ferrous metals such as carbon steels, alloy steels, low chromium steels, and manganese steels. Steels with a high tungsten or chromium content or stainless steel cannot be cut with oxyacetylene heat. Cast iron is more difficult to cut than steel; therefore, an excessive acetylene flame is used to cut thick cast iron. Also more oxygen is needed due to more heat being required than when cutting malleable steel. The cutting tip is held at 45 degrees to start the cut and is raised to about 75 degrees to make the cut.

c. The steps to follow in making a cut are:

(1) Hold the blowpipe perpendicular to the surface of the metal unless bevels are to be cut. Place flame inner cone within 1/16 to 1/8 inch above the plate or metal surface edge. Metal will not stack on the tip if it is held at a proper distance from the surface. Hold the tip so that two preheating holes are in line with the oxygen hole.

(2) Hold the torch at the edge of the metal until the metal begins to melt. The top of the torch may be slanted toward the cut and changed to a vertical position as the cut progresses.

(3) Press down slowly on the oxygen cutting lever until the cutting valve is completely open. When the cut is through the metal, move the torch along the line.

(4) Tilt the torch tip slightly toward the direction of cut on thin metal. It should be held vertical on thick metal when making a straight cut.

(5) Move the torch slowly along the surface or the oxygen stream will not pass completely through the metal. The cut can be restarted by releasing the cutting lever and reheating the metal again before pressing the cutting lever. Irregular edges may be caused by losing the cut.

(6) When beveling plate edges or cutting at an angle, lean the tip at the desired angle and hold the torch parallel to the work.

d. Steps that may be followed when piercing holes include:

Transparencies Nos. 4 and 5

(1) Hold the blowpipe in the same position (tip perpendicular to the surface) until a spot on the surface begins to melt.

(2) Raise the blowpipe (torch) until the end of the nozzle is about 3/8 to 1/2 inch above the surface and slowly press the cutting lever as the torch is raised.

(3) Move the tip to one side of the heated area so that the slag (non-metallic material in the heated metal) can be blown out.

(4) Move the inner cone within about 1/8 inch from the surface and make the cut on the inside edge of the hole.

(5) To facilitate the cutting of a hole in thick metal, drill a hole 1/4 inch or larger by using a twist drill and start the piercing in this hole.

8. Lighting and Adjusting the Welding Blowpipe

Transparency No. 6

a. Steps to observe when lighting the blowpipe include:

(1) Hold the torch in one hand and the friction lighter in the other. The welding goggles should be pulled from the forehead over the eyes.

(2) Open the torch acetylene valve about 1/8 to 1/4 turn with the tip pointing away from the body and cylinder. The lighter should be held about an inch from the point of the tip while lighting the torch.

(3) Open the acetylene valve until the flame stops excessive smoking and breaks away from the tip about 1/8 inch. The flame is then reduced slightly to bring it back to the tip. The valve is opened again very slightly. If there is a backfire, the flame will go out with a pop. Check the pressure, connections, and heated tip to correct problem.

(4) Open the oxygen valve slowly until a sharp inner cone appears, creating a neutral flame. The neutral flame is recognized as the oxyacetylene welding flame. Even though the neutral flame is used for most welding jobs, the carburizing flame is used for hard surfacing. Flame descriptions are as follows:

(a) Neutral Flame - This flame does not show any acetylene feather. It does not have a feathery edge, but the flame has a sharp inner cone.
(b) Carburizing Flame - This flame is caused by using an excess of acetylene. It has an inner cone and an acetylene feather. It is the largest of the three types of flames, and is usually the first flame to appear when lighting the torch.
(c) Oxidizing Flame - An oxidizing flame has an excess of oxygen. The small inner cone has a sharp point. The main body of the flame is smaller than the other two types of flames. The flame may be used for braze welding with a bronze rod.

If the oxygen low pressure gauges show there is a lack of oxygen, turn the regulator valve clockwise until the coneshape flame becomes blue; adjust the torch valve until a neutral flame appears.

9. Turning Off the Blowpipe (Torch)

a. First the acetylene valve is closed on the torch and then the oxygen valve is closed. This assures the operator that the flame is out, thus reducing the possibility of a flash-back which is caused by a carbon deposit in the tip.

b. The oxygen torch valve is the second valve closed. This procedure is followed by closing the acetylene and oxygen cylinder valves.

c. The acetylene and oxygen torch valves are opened to release hose pressure and then they are closed again.

d. The acetylene and oxygen regulator adjusting screws are backed out until they are loose.

10. Caring for Welding Tips

a. Welding tips frequently become spattered with metal or other materials that may cause inferior work. Tips are cleaned in the following manner:

(1) The tip point can be rubbed with emery cloth or steel wool; foreign material and metal is removed by this method. The emery cloth may be placed on a flat surface with the grit side up and the tip point passed squarely over it.

(2) Tip cleaners should be used to clean the orifice of the tips. The edge of the orifice should remain square. The cleaner should have the same number as the tip.

(3) If the oxygen valve is opened slightly at the time the tip cleaner is carefully pushed in and pulled out of the opening, the foreign particles will be blown out of the tip.

b. Proper handling of the tip

(1) The threads and seats of tips can be damaged easily; therefore, they should be stored in a rack for protection.

(2) Most tips can be replaced in a welding blowpipe by hand; but if a wrench is needed to set the tip, it should not be overtightened.

(3) Care should be observed when inserting the tip into the blowpipe. Tip threads are very easily damaged; crossthreading will ruin the tip.

11. Preparing Metal for Welding and Proper Positions of Blowpipe and Tip

a. Preparing metal for welding is as follows:

(1) Before a good weld can be made the metal must be free of oil, paint, grease, dirt, rust, and other foreign matter. Metal can usually be cleaned by heating it with the torch and then brushing it with a wire brush.

(2) Thick metal over 1/8 inch thick can be beveled on one or both sides either by using a grinder or by the use of the oxyacetylene cutting torch. Beveled edges will allow the metal to fuse together and make a stronger joint. Metal over 1/2 inch thick should be beveled on both sides. The most common types of bevels are: Single, Double, Single Vee, and Double Vee. Most bevels are cut at about 45 degrees.

(3) Some types of work require that the metal be aligned before welding; therefore, tack welding is necessary to hold the metal in line during the welding operation. The tack welds may become part of the finish weld.

b. Proper blowpipe and tip positions are:

Transparency No. 6

(1) The blowpipe may be held similar to a hammer when welding in a standing position. It can be held like a pencil when welding in a sitting position.

(2) The blowpipe should be held so that the tip will be at a 45-degree angle to the surface. The welding rod should also be held at about a 45-degree angle to the surface and in line with the weld.

(3) The tip should be held about 1/4 inch above the surface. The inner cone flame should be 1/8 inch to 1/16 inch above the metal.

(4) Preheating the metal is very important in making a successful weld; therefore, the flame should be moved in the direction of the weld, and the cone should stay inside the puddle (molten pool of metal).

12. Oxyacetylene Welding Procedures

Transparency No. 7

One of the most important steps in learning to weld with oxyacetylene is to carry a molten puddle of metal along the line or seam of the parts to be joined together by the weld.

a. Forming the puddle and running the bead include the following practices:

(1) The flame is held at the starting point until a bright round pool (1/4 to

3/8 inches in diameter) is formed. This puddle width is actually determined by the depth of penetration and motion of the torch. If a 3/16 inch wide puddle or pool is formed, the speed of welding should maintain that width. If the speed is correct, the puddle will be formed under the inner cone of the flame. Usually, the inner cone is held from 1/16 to 1/8 inch above the surface. If the speed is too slow, the torch flame will burn a hole through the metal or form a large pool. If the speed is too fast, the blade will be irregular and narrow.

(2) There are several types of torch movement patterns, but the most common pattern used by the experienced weldor is the circular motion, especially when fusion welding with the torch is being done. The weaving or zigzag pattern is also used when fusion welding, but with the use of a filler rod. When using either pattern, the torch should be held at about 45 degrees to the surface or weld. The welding fiber rod should be held at 45 degrees but slanted away from the torch tip.

It is recommended to use a rod equal to the thickness of the metal. The torch may be held so the tip is pointed in the direction of the weld (forehand) or the tip pointed toward the weld (backhand).

(3) After a bead is finished, it should be examined for the following characteristics:

(a) Uniform width
(b) Free of excessive scaling
(c) Clean and bright
(d) Slightly higher than the base metal surface and penetrating the base metal

b. When using a welding rod to make a fusion weld the following procedure may be used:

(1) Select two pieces of 16-gauge sheet steel about 3 inches long and 2 inches wide and a 1/16-inch filler rod.

(2) Slightly bevel the 3-inch sides and tack weld at each end, leaving a very small space (about 1/16 inch) between the two pieces.

(3) With the torch in one hand and the welding rod in the other, heat the two pieces at the starting point (one end) and then heat the welding rod before dipping it into the molten puddle. Make an up and down motion of the rod and at the same time make a circular or zigzag motion with the torch. When using the circular motion remove the rod from the puddle as the flame is moved to the rear of the puddle. Before starting the weld, heat

the rod 8 inches from the welding end and bend it at this point to about a 120-degree angle. It is easier handled in this shape.

(4) As the second tack weld is reached, remelt it into the pool or puddle.

13. Welding Positions

Transparency No. 8

Learning to make a welding bead is the first step in learning to master the skill of oxyacetylene welding. The second important step in mastering the skill is to become proficient in welding in several positions. The four most important positions are:

a. Flat Position - The flat position is practiced while learning to weld a bead and fuse metal without the use of a welding rod. This position is known as the downhand position. The following steps are used to make a flat weld:

When welding heavy metal, hold the torch in the manner a hammer is held. If the metal is thin, hold the torch in a pencil manner.

The flame is pointed in the direction of the weld at about a 45-degree angle.

A right handed weldor usually starts the weld at the right edge of the metal. The inner cone of the neutral flame is usually held within 1/8 inch of the surface to be welded.

The torch is moved forward and rotated at the same time to form a series of overlapping ovals at the back edge of the puddle. The torch should not be moved ahead of the molten metal (puddle). The welding rod should be raised and lowered as the puddle is moved forward.

The welding rod is held at about a 45-degree angle ahead of the torch. A bent rod is easier to handle than a straight rod in front of the flame.

The rod tip is inserted in the molten pool of base metal, where it is melted. A weak porous weld is caused by the rod metal being burned above the puddle.

The welding rod must be held in the center of the puddle, otherwise it will have a tendency to stick.

In order to form a bead of uniform width and height, the puddle must be carried forward just right. If the movement is too fast, the rod will not fuse with the base metal. If the movement is too slow, the puddle will be too large.

When a puddle is too large, withdraw the flame so that the outer envelope (outer part) touches the molten metal. Do not move the entire flame alloy from the puddle. Air causes the hot metal to oxidize.

The types of welds that are common to the flat position are:

- Butt
- Corner
- Lap
- Fillet

b. Vertical Position - Vertical welding is usually done by welding from the bottom up.

Hold the torch so that the tip will point upward at approximately a 15 to 30-degree angle. The rod is held at about the same angle in the other direction.

Make a very small motion with the tip so that the gas velocity will keep the molten metal in place. A large torch motion will cause the molten metal to sag or fall. If the puddle gets too fluid, the flame is directed toward the filler rod.

c. Horizontal Position - The torch and rod are held at about the same angle to the metal as when welding in the flat welding position.

Point the torch tip slightly upward and direct the flame along the lower edge of the two pieces of metal. The position of the torch will help reduce a build up of metal on the bottom piece. Weave the flame from one side of the bevel to the other, holding it slightly longer on the lower edge.

Add metal to the weld from the welding rod by the same procedure that is used in vertical and flat welding.

d. Overhead Position - Overhead welding is more difficult than flat welding, but it is not much harder than vertical or horizontal welding. It is the most difficult position to actually see the weld while it is being done.

Hold the tip at approximately 90 degrees to the work and hold the rod at approximately a 45-degree angle.

Maintain a shallow puddle to eliminate molten metal dropping from the weld. Usually less heat is required than welding in the flat position.

Use a semicircular motion with the torch and move the rod in a circular swinging motion.

If the puddle becomes too large or fluid, raise the torch flame. The flame should be directed to the center of the work instead of one side.

The weld is usually made by moving the torch from right to left.

14. Selecting the Proper Size of Welding Tip and Size of Rod for Certain Thicknesses of Metal

Tips are made in various sizes to provide different degrees of heat. The amount of heat increases as the size of orifice (drill size of a hole in the tip) increases. The neutral flame will remain at about 5,900 degrees even though the quality of heat may change. The use of the proper tip size is very important for making a good fusion weld.

Listed below are the approximate size of tips and rods to use when welding steel.

Tip Size (Orifice)	Rod Size (Inches)	Thickness of Metal (Inches)
74	1/16	1/32
69	1/16	1/16
64	3/32	3/32
57	1/8	1/8
55	3/16	3/16
52	3/16	1/4
49	1/4	5/16
45	1/4	3/8
42	1/4	1/2

15. Making the Common Types of Welds

Transparency No. 9

a. Butt Weld - Butt joints are made by placing the edges of metal material together. If the metal is less than 1/8 inch thick, it is usually not necessary to bevel the edges. The steps in making a butt weld are:

Bevel the edges or groove out the place that is to be welded to insure proper fusion and penetration.

Space butt joints far enough apart to allow normal expansion (1/16 inch for 1/8 inch thick steel plate) when heated.

If two separate pieces of metal are welded together, they should be tacked together. Hold the rod and blowpipe at about 45-degree angles; heat the areas to be tacked until two small puddles appear on the two pieces. Add filler metal from the rod and bridge between the two small puddles.

Remove the flame to permit the metal to solidify. It may be necessary to tack weld long pieces of metal in several places.

Examine the finished butt weld to see if it is of uniform width, height, and ripple. Examine the underside for even penetration. A good steel weld will bend 90 to 180 degrees before breaking.

b. Corner Weld - Corner welds may be made without the use of a fusion rod. If two pieces of metal are placed together with the inside corners touching, a perfect trough or vee is formed for using a filler rod. Steps involved in making a corner weld without and with a filler rod are:

Place the inside corners of two pieces of metal together to form a vee. Tack the edges.

Hold the torch so that the tip is pointing in the direction of the weld at about 45 degrees. Form the puddle at the right end of the joint. A left handed weldor may start the weld at the left end of the joint.

Move the torch in a weaving motion and slow enough that both pieces of metal will be fused together.

When using a filler rod to make a corner weld, space the metal pieces about 1/16 inch apart to get the proper penetration.

Weld a bead slightly thicker than the base metal.

Examine the weld for defects. Corner welds may be made stronger by beveling one piece of the metal.

c. Lap Weld - Lap welds are made by overlapping pieces of metal. It is considered a strong type of weld. The edges of one plate are welded to the face of another plate. Use the following steps to make a lap weld:

Overlap two pieces of metal and tack the edges to the face of each piece.

Hold the rod and the welding tip at about the same angle as when making butt welds.

Move the torch in the same way as when making a butt and corner weld; however, it is necessary to control the flame to prevent melting the edges of the top plate while forming the puddle in the bottom of the vee.

Weld both overlapping edges to give the lap joint strength.

d. Fillet Weld - The fillet weld is commonly known as the T weld. It is made by welding pieces of metal together at a right angle. Generally, the lap and corner welds may be classed as fillet welds. The weld is made similarly to the lap weld, in that the puddle must be welded equally on both pieces of metal. The steps for making this weld are:

Tack two pieces of metal together in the form of a T.

Start the puddle at the right-hand end of the joint. Move the torch in an oval motion to melt both pieces at the same time.

Move the flame along the joint and direct it more to the flat piece of metal than the upright piece. The torch is held at about the same angle as when welding a lap joint.

Filler rod is added to the fillet weld in the same manner as the lap weld; as the puddle forms in the corner, the filler rod is added. The metal should be at the same height on both plates.

16. Forehand and Backhand Welding Methods

Transparency No. 10

a. Forehand Welding - In the forehand method, the filler rod is moved ahead of the blowpipe tip from right to left (right-handed weldor). The flame is pointed in the direction of the weld.

This welding method may be used to an advantage for thin material, due to the flame pointing away from the weld and the rod helping to control the heat ahead of the molten pool. The main disadvantage of this method is that beveled edges must be completely melted to provide adequate fusion of the filler rod and base metal.

Uniform heat is provided along the path of the weld by manipulating the torch tip in a semi-circular back-and-forth movement. The rod may be moved up and down, avoiding the welding cone tip, but keeping it inside the outer flame envelope. The rod may also be moved in a back-and-forth motion.

b. Backhand Welding - The movement of the torch and rod are from left to right (right hand weldor) when welding by this method. The rod is held between the completed weld and the flame, and the flame is pointed in the direction of the completed weld.

A back-and-forth movement of the torch and rod to the edges of the bevel may be used. If the flame is directed properly on the edges of the vee, this movement may not be necessary. However, it is necessary to manipulate the filler rod (oscillating motion) from side to side in the puddle.

Usually a 60-degree vee is sufficient to do backhand welding. Forehand welding requires a wider vee; therefore, more filler rod is needed. Also, more fuel and time is needed to weld a wider bead when using the forehand method.

It is easier to burn through the vee when using the backhand technique than when using the forehand technique. Some authorities state that backhand welding is the best method of welding for deep penetration and complete fusion of thick metals.

17. Welding Sheet Steel

Many farm machine bodies are made of sheet steel. Cracks and torn places on combines, balers, tractors, trucks, and many other types of machines may be repaired by the oxyacetylene welding process. The welds can be as strong as the base metal when properly made. Regardless of the thickness of the metal, it is advisable to use a filler rod in order to obtain a strong weld. The procedure for welding sheet steel is as follows:

Transparency No. 11

a. Adjust the torch to a neutral flame and select the proper size rod for the metal to be welded. For example, use a 3/32 inch rod for 3/32 inch metal.

b. Direct the torch flame in the direction the weld is to be made. Position the white cone so that it does not quite touch the metal.

c. Hold the torch in one place until a small puddle forms and the metal begins to flow together.

d. Preheat the filler rod by placing it within 3/8 inches of the flame and about 1/8 inch from the puddle.

e. Dip the end of the rod into the puddle as metal is needed in the weld. Add enough rod metal to form a slight crown.

f. Withdraw the rod as described previously, but keep it in preheat distance of the flame.

g. Move the torch forward at a constant speed, keeping the slant the same, and add filler metal at consistent intervals.

h. Move the flame in a small circle or make a zig-zag motion with the tip to help spread the heat evenly and cause the metal on both edges to fuse properly. Move the rod in an up and down or zig-zag motion.

When welding cracks or torn places on farm machines, the joints may be made stronger by reinforcing with a strip of metal. All metal should be free of grease, paint, dirt, and rust before attempting a weld. Edges or thin metal should be brought together before starting a weld. The edges should be tacked. The tack welds should be 2 to 4 inches apart.

If overheating signs appear or puddles melt through, a smaller tip should be used or the acetylene pressure reduced.

18. Welding Heavy Steel Plate

There are many places on farm machines where steel over 1/4 inch is used. Welding heavy steel plate requires knowledge and skill in handling a large amount of heat, large puddle, and a large amount of filler metal. Welding thick steel is also different from welding thin steel in the following ways:

Joints should be beveled; multi-lay welding is required for large vees; good fusion must be maintained up the sides of the vee; and a different welding technique (backhand) may be used. The procedure for welding heavy steel plate is as follows:

a. Bevel the edges so that they form a single bevel if the metal is less than 1/2 inch. The angle for both pieces of metal should be between 60 and 90 degrees. Make a double-vee joint on metal over 1/2 inch thick. Bevels are made with a cutting torch. Remove all slag and scale from the bevels. Leave a root face (straight edge at bottom of bevel) of about 1/16 to 1/8 inch on single and double vee edges.

b. If the steel plate or heavy metal is in two complete pieces, space the pieces about 1/16 inch apart for welding.

c. Select the filler rod according to the thickness of metal. For example, use a 1/4 inch rod on 1/2 inch metal. A No. 42 tip is recommended for welding 1/2 inch metal.

d. Tack weld the metal at each end of the weld if the welding distance is 3 or 4 inches. If the welding distance is several inches, tack welds should be every 2 to 4 inches.

e. Melt a puddle at one edge of the plate, heating both sides evenly. Use either the forehand or backhand method for welding the bead.

f. Bring the filler rod into the line of heat as previously mentioned in welding thin metal. Heat the filler rod near the melting point and introduce it in the puddle.

g. Place a bead the full length and in the bottom of the vee. Use a zig-zag or circular motion with the blowpipe and move the rod back and forth in the puddle.

h. Make a second bead (weld) in the reverse or same direction but in the same manner as the first bead. Fill the vee almost full of filler and base metal.

i. Reverse the direction of travel and place a third layer of metal on the second layer. Fill the vee slightly above the surface of the plate or object that is welded.

j. If there are parts on machines made of high carbon steel (0.80 percent carbon), the areas should be preheated to a red color and welded with high carbon rods. Machines springs are made of high carbon steel.

19. Welding Gray Cast Iron

Many machine parts are made of cast iron. Machinery gears, frames, gear boxes or housing, and engine blocks are made of gray cast iron. It is important that a machine repairman be familiar with processes involved in repairing cast iron parts on machinery and equipment.

Cast iron oxyacetylene welding procedure is as follows:

Transparency No. 12

a. Clean the cast iron area to be repaired of paint, dirt, and grease. Partial cleaning may be done with the torch and a steel brush.

b. Match the parts to be welded and cut, chip, or grind a bevel along the break line. Grind the beveled surface if a torch is used to make the cut.

c. Preheat the entire area to a dull red before welding. Preheating helps prevent cracking of the metal during the cooling period. Move the flame slowly over the area to be welded. Small areas can be heated by the torch; large areas must be heated in a furnace. If possible postheat the metal and let cool slowly. Cover the welded area with asbestos paper until it is cool.

d. Select the proper size tip for the job. The size of tip used for steel can be used for cast iron.

e. Select a cast iron rod that contains the proper amount of silicon. These rods are available in 1/8 and 1/4 inch diameter by 18 and 24 inches in length. A high quality alloy cast iron rod will contain enough silicon.

f. Apply the neutral flame heat to the bottom of the vee until the metal begins to melt. Hold the torch in about the same position as in welding steel. Keep the inner cone from 1/8 inch to 1/4 inch away from the seam.

g. Move the rod from side to side and melt down the metal so that it will combine with the fluid metal in the bottom of the vee.

h. Move the torch in a circular motion to keep the metal fluid. If the fluid metal appears too hot or tends to run away, raise the torch to reduce the heat.

i. Bring the filler rod into the outer flame and as soon as it is hot, place the end into the cast iron welding flux.

j. Return the flux end to the molten puddle. The molten metal will rise in the vee as the rod melts. Do not continue dipping the end of the rod in the puddle at the same speed as when welding steel. The molten puddle may be stirred with the end of the rod to bring oxides and gas pockets to the surface. Play the flame to bring impurities to the top of the weld.

k. The motion may also be oscillating with both rod and torch as the weld is advanced inch by inch.

l. Bring enough cast iron rod and base metal together to form a slight crown. Generally, no ripples will appear on the surface of a cast iron bead.

20. Welding Aluminum

Aluminum and aluminum alloys are used in the manufacturing of machine parts and different types of small engines. Some of the ways that aluminum differs from other metals are:

It oxidizes with ease at high temperatures, melts before it changes colors, conducts heat faster and shrinks more on cooling than cast iron, and becomes very weak near the melting temperature.

The characteristics of a good steel joint weld apply to welding an aluminum joint. These characteristics are:

Proper fusion
Proper penetration
Weld in line with seam
Proper crown
Clean appearance

The procedure for welding aluminum is as follows:

Transparency No. 13

a. Prepare straight flanged joints when possible before welding sheet aluminum less than 1/16 inch thick. Notch joints on sheet 1/16 to 3/16 inch. Notches may be made with a hacksaw or chisel. Notches help prevent distortion, aid penetration, and reduce the possibility of burning holes through the pieces of materials.

b. Bevel the edges of joints if the aluminum plate is over 3/16 inch thick. Cut notches at the lower part of the bevel. The edges may be beveled to form a 90 to 120-degree vee. Leave a 1/16 inch root space on aluminum plate. Double - vee bevels are notched on metal more than 3/8 inch thick. In general, the edges of steel and aluminum are prepared for welding in the same manner.

c. After the edges have been cleaned, jig the material to keep it from buckling and collapsing when heat is applied.

d. Preheat the area to be welded on cast aluminum regardless of the thickness. Preheating will minimize cracks and reduce expansion. Move the flame over the work to preheat the material. One of the well known methods to determine the proper preheating temperature is to mark the preheating area with carpenter's blue chalk and heat the material until the chalk turns white.

e. Use a tip slightly larger than is recommended for steel of the same thickness. Adjust the flame to neutral or slightly reducing. Never use a "blowy" flame.

f. Select the proper rod for welding. A filler rod equal to the thickness of the metal is usually used. The four most common sizes of rods are: 1/16, 1/8, 3/16, and 1/4 inch diameter. Commercially pure aluminum is welded with 1100 welding rod. Aluminum that contains alloys is welded with 4043 or 5356 welding rods.

g. Make a paste flux by mixing three parts of aluminum flux in one part of water. Coat the metal and the welding rod with the paste before starting the weld. The fumes from the flux can be dangerous. The weldor should avoid breathing the fumes.

h. Adjust the flame to neutral or slightly carburizing so that the metal will not oxidize. If the flame is greatly reduced, the metal will have a dirty appearance.

i. Melt the flux over the surface to be welded with the torch. Melt the base metal and then apply the rod. The rod should remain under the flame long enough to deposit the rod metal. Use a circular motion to weld the bead. Forehand welding is considered the best method for welding aluminum, because the forward flame helps preheat the base metal.

Cast aluminum is welded in about the same manner as wrought aluminum. A steel paddle may be used to stir the molten metal, remove oxidized aluminum, and smooth the surface of the bead.

21. Bronze Welding

Transparency No. 14

Most repair and rebuilding jobs on farm machines can be accomplished by bronze welding. It is a convenient way to join steel, malleable steel, cast iron, and several other metals together.

Bronze welding is very frequently referred to as braze welding or brazing. The American Welding Society defines braze welding as "A method of welding whereby a groove, fillet, plug, or slot weld is made using a nonferrous filler metal, having a melting point below that of the base metals, but above 800 degrees F. The filler metal is not distributed in joint capillary attraction."

Bronze welding resembles soldering in that the base metal is not melted together with the bronze metal. There is a strong bond formed between the base metal and rod metals in a proper weld.

The advantages of a bronze weld are:

Lower welding temperatures are needed; therefore, time and gas is saved.

Due to the low temperature used to make a bronze weld, there is less chance of changing the base metal characteristics. For example, expansion and contraction are not as great where less heat is required.

Less preheating is used in bronze welding than wrought or cast iron welding.

Bronze welding is adaptable to many kinds of metals.

The disadvantages of bronze welding are:

The bronze weld may not withstand the same amount of stress as a steel weld.

Bronze tends to lose its strength if subjected to temperatures above 500 degrees F.; therefore, parts on a machine that operate at high temperatures should not be welded with bronze. The filler rod is made up of copper and zinc with small quantities of silicon, tin, iron, and manganese.

The procedure used in bronze welding is as follows:

a. Free the surface to be welded of any grease, paint, dirt, corrosion, or rust. The molten bronze will flow over a properly heated and clean surface. The surface may be cleaned by grinding, sanding, filing, chipping, or a combination of these cleaning processes.

b. Prepare the joint to be welded in the same way as preparing joints for other welding processes. Butt, lap, and tee joints are welded without beveling if the base metal is less than 1/8 inch thick. Bevel metal that is over 1/8 inch thick. Butt welds should be spaced about 1/15 to 1.8 inch apart. A larger bonding area is provided if the vee-groove is at least 90 degrees. Metal that measures more than 3/8 inch thick should be double beveled.

c. Select the proper size welding tip for a specific job. Different thicknesses of metals require different sizes of tips. A tip that is too large will burn the bronze and cause it to flow too freely over the joint. Listed below are tip sizes for bronze welding:

Size of Tip (Orifice)	Size of Rod (Inches)	Thickness of Metal (Inches)
69	1/16	1/16
57	1/8	1/8
52	3/16	1/4
45	1/4	3/8
45	1/4	1/2

d. Use a slightly oxidizing flame for bronze welding. Light the blowpipe with an excess feather of acetylene. Add oxygen until feather disappears; then add just a small amount more oxygen. Point the tip of the blowpipe in the direction of the weld and angle it at about 45 degrees. Do not operate the blowpipe at high pressure.

e. Preheat castings with the torch to a cherry red. Move the bronze rod into the outer flame and heat before dipping it into the flux. When welding two separate pieces (butt weld) together, tack weld the pieces, spacing the tacks a few inches apart. There is a special flux for most metals. Under certain conditions flux may be sprinkled on the metal and heated.

f. Move the flame in an arc or oval and move the rod back and forth in the opposite direction from the flame. Keep the rod close enough to the flame that it will not freeze. Each time the rod is melted to the end of the flux, heat and dip it again.

g. To do proper tinning (thin film of metal) the correct amount of heat, adequate amount of flux, and adequate amount of bronze must be used over the surface to be welded. Proper tinning is very important when welding cast iron. A thin layer of the bronze molten metal adheres to the cast iron, forming a footing for the succeeding weld.

h. Make as many passes as necessary to fill the vee or weld. The final bead should make a slight crown.

22. Hard Surfacing Practice Procedure

Hard surfacing is the application of an all alloy material to another metal for the purpose of reducing wear. Metals that are subjected to abrasive wear such as cultivator sweeps, plow shares, and horseshoes can be hard surfaced.

The procedure for hard surfacing is as follows:

Thoroughly clean the metal before applying alloy.

Place the material to be hard surfaced in a flat position.

Heat a small section of the area with a welding flame that contains an excessive amount of acetylene until the metal begins to sweat.

Touch the tips of the alloy rod to the surface and melt enough of the rod to form an alloy cover 1/16 inch thick and a desirable width without heating the base metal to a melting point.

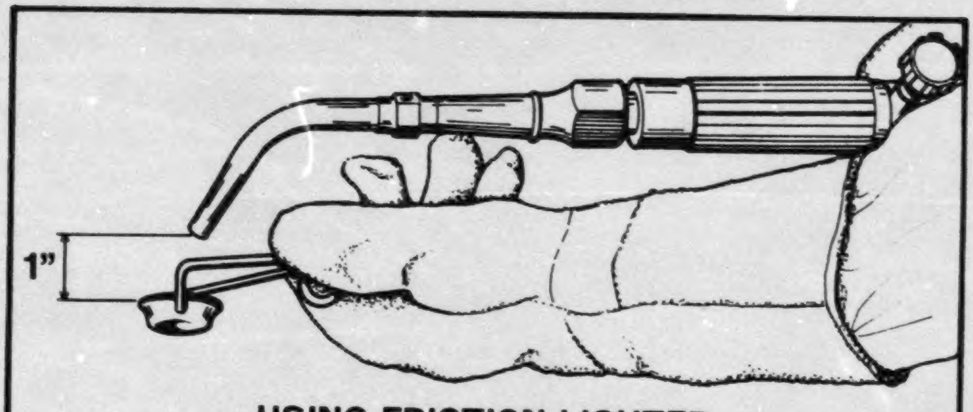
Maintain a hard surfacing temperature in front of the path of the hard metal. Add just enough of the rod to the metal to maintain a uniform thickness and width. The width will vary according to the material being welded.

Hard surfaced metal should be allowed to cool slowly. Ashes or dry lime serves as a good cover for cooling metal.

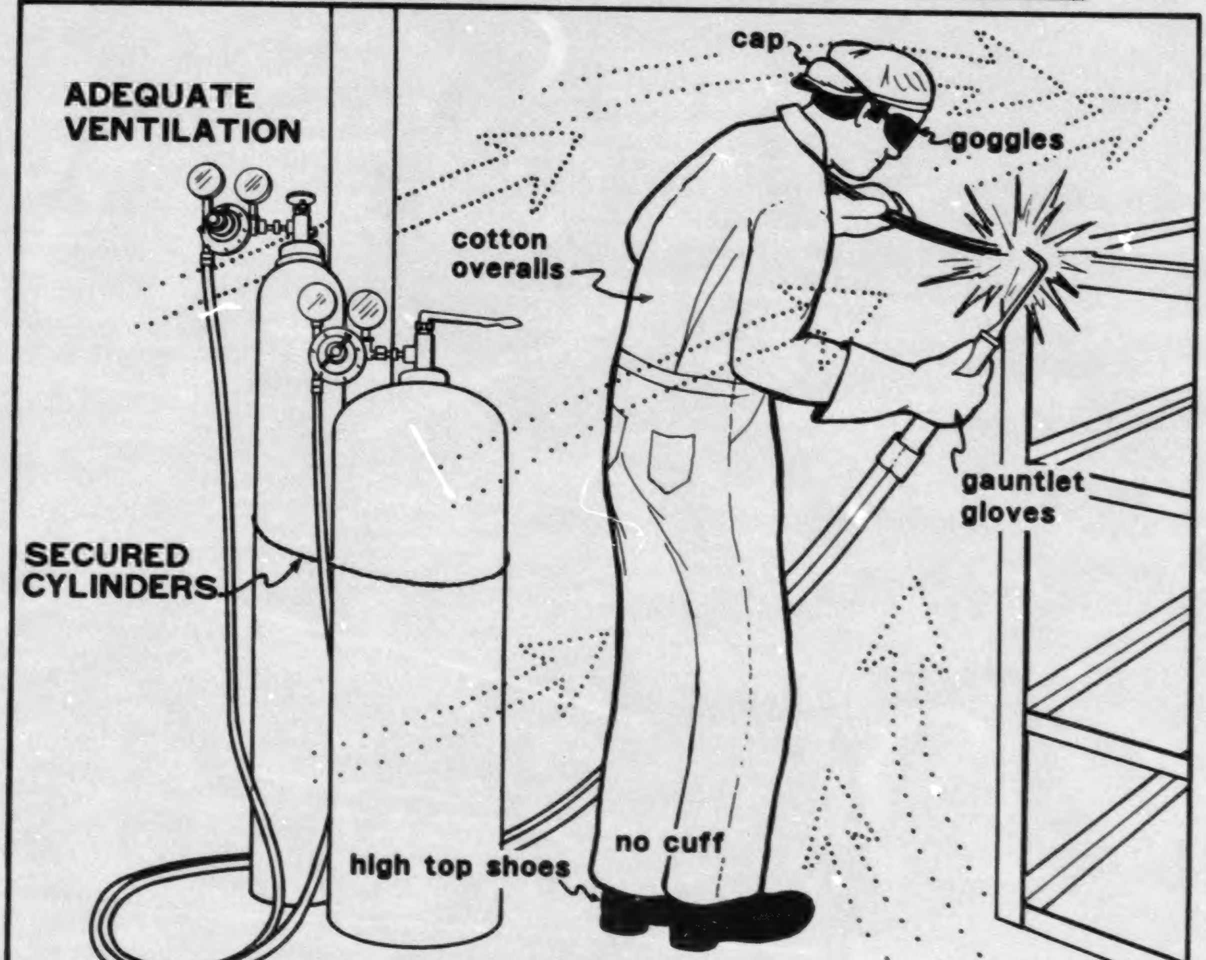
References:

1. Althouse, Andrew D., and Others, Modern Welding, The Goodheart-Willcox Company, Inc., South Holland, Illinois, 1976
2. Griffin, Ivan H., and Edward M. Roden, Welding Processes, Delmar Publishers, Inc., Albany, New York, 1970
3. Morford, V. J., and Others, Metals and Welding in Agriculture, Hobar Publications Division of Hobar Enterprises, Inc., St. Paul, Minnesota, 1970
4. "The Oxy-Acetylene Handbook" Union Carbide Corporation - Linde Division, New York, 1972

SAFETY PRACTICES

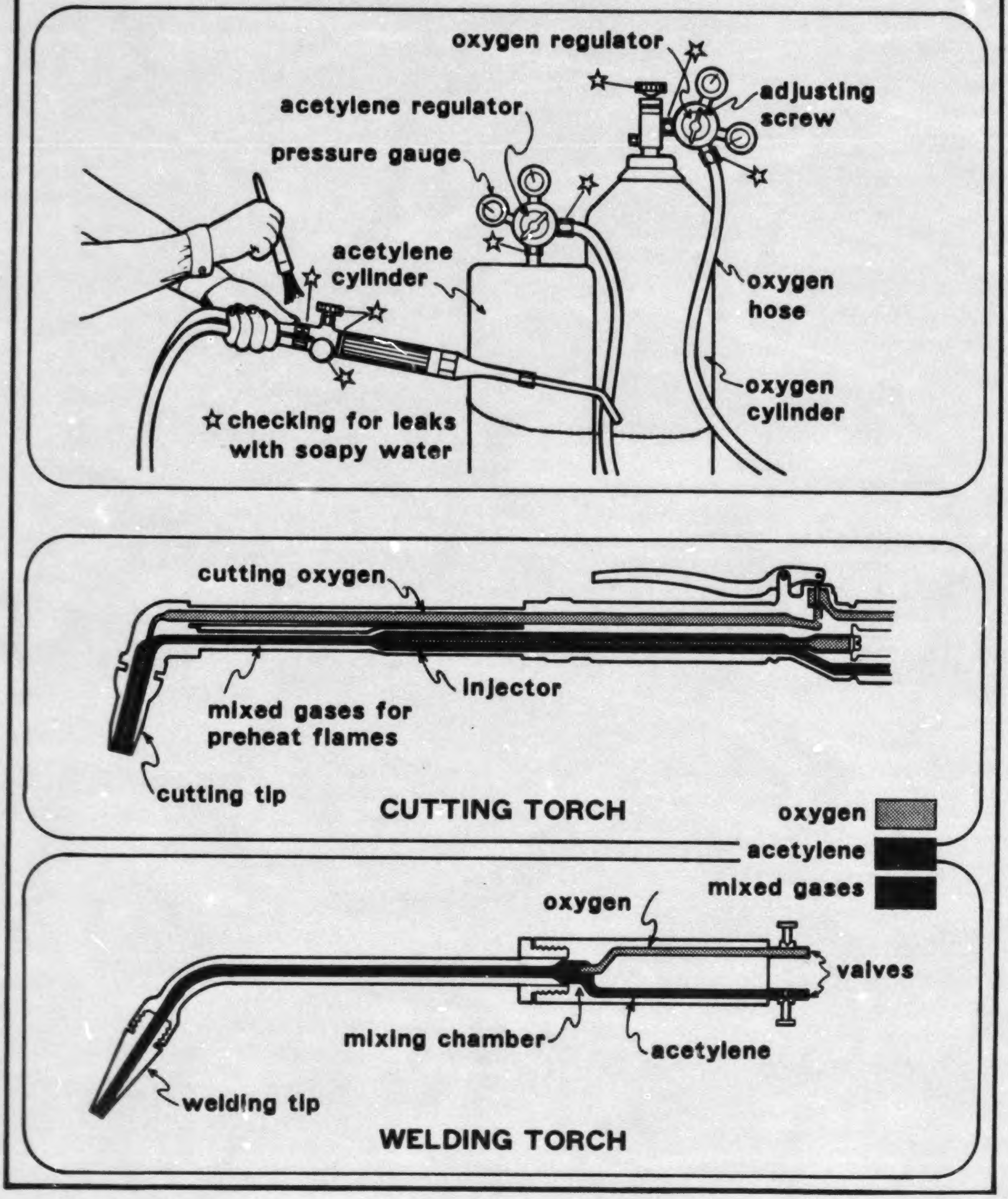


USING FRICTION LIGHTER

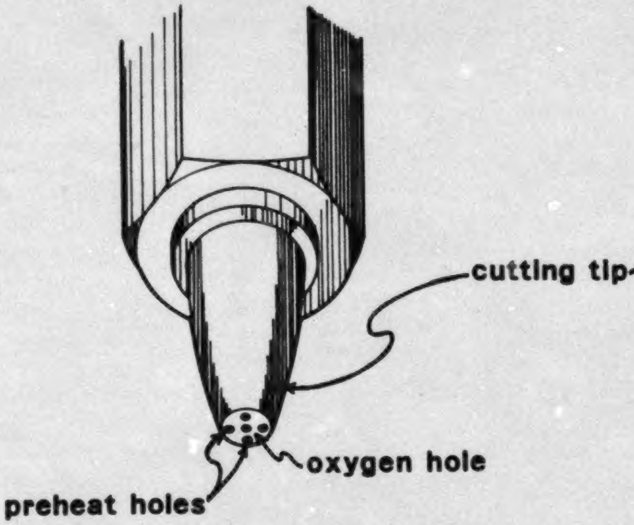

ADEQUATE VENTILATION
cap
goggles
cotton overalls
gauntlet gloves
SECURED CYLINDERS
high top shoes
no cuff

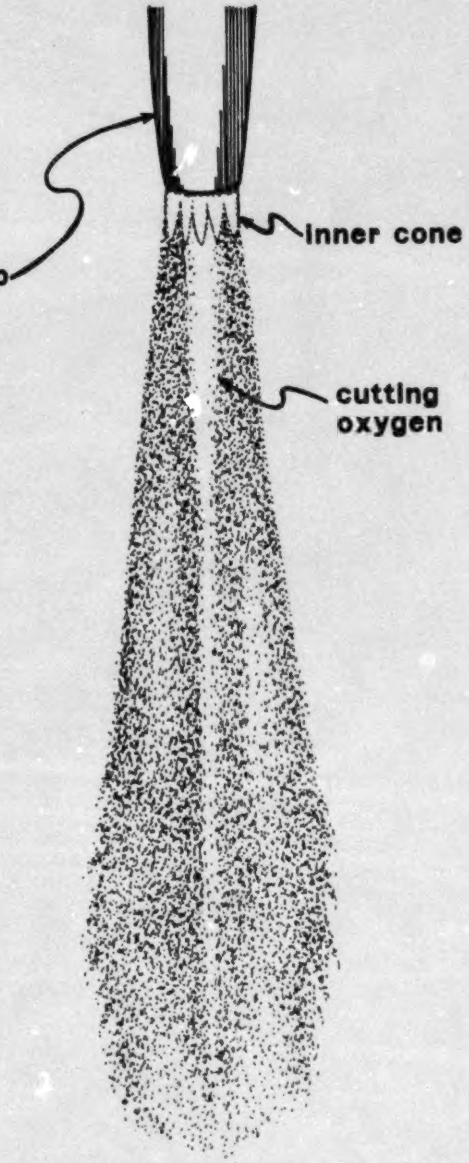
PROPER DRESS

OXYACETYLENE EQUIPMENT

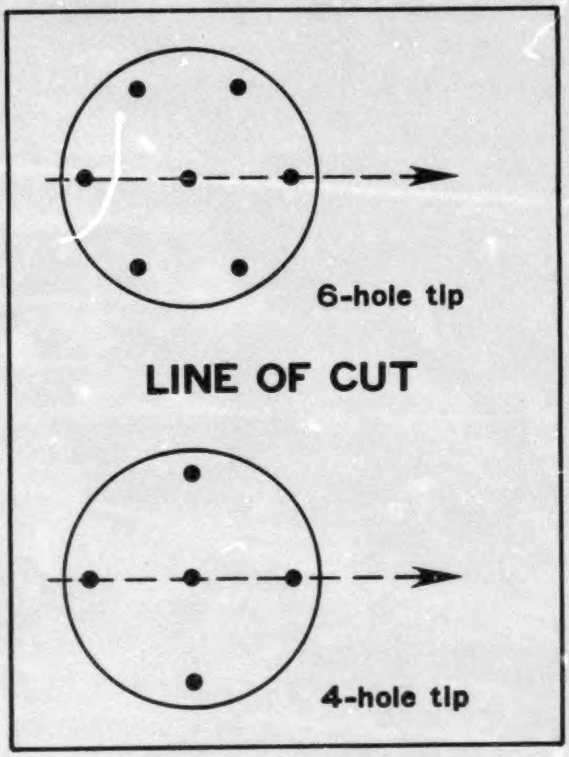

oxygen regulator
acetylene regulator
adjusting screw
pressure gauge
acetylene cylinder
oxygen hose
oxygen cylinder
☆ checking for leaks with soapy water
cutting oxygen
injector
mixed gases for preheat flames
cutting tip
CUTTING TORCH
oxygen ▨
acetylene ■
mixed gases ■
oxygen
valves
mixing chamber
acetylene
welding tip
WELDING TORCH

OXYACETYLENE CUTTING

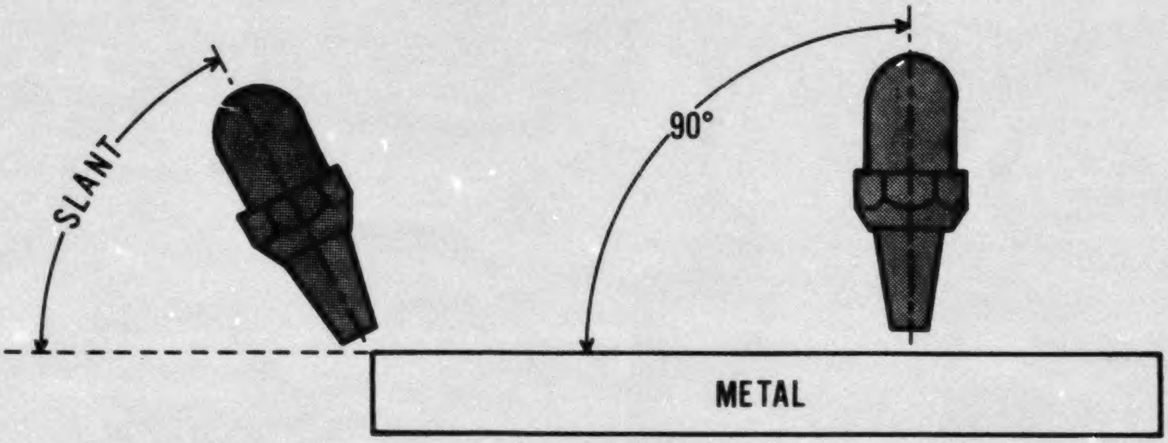

cutting tip
oxygen hole
preheat holes


inner cone
cutting oxygen

NEUTRAL FLAME
WITH
CUTTING JET OPEN

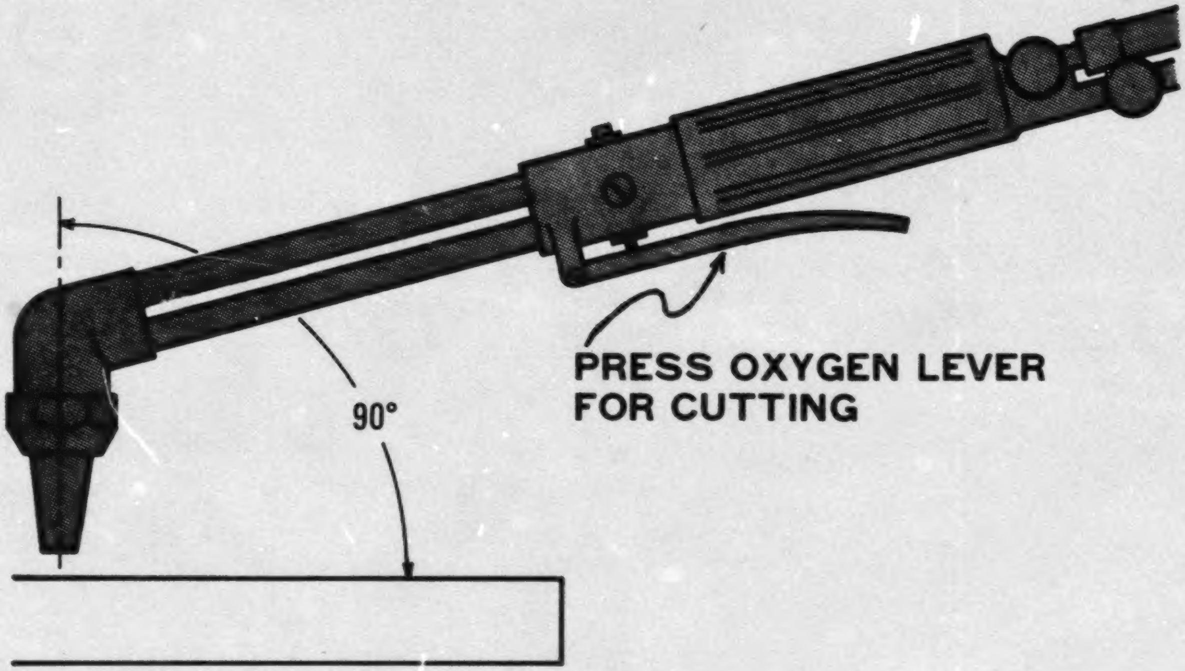

6-hole tip
LINE OF CUT
4-hole tip

CUTTING METAL



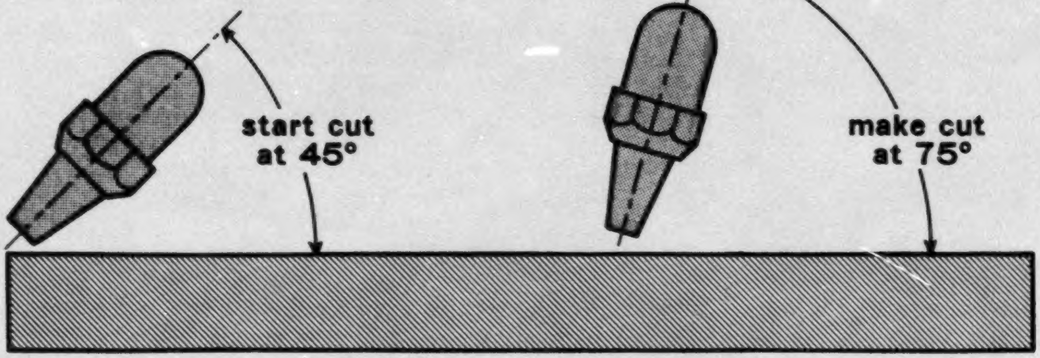
TORCH TIP SLANTED TO START CUT

GRADUALLY MOVE TORCH TIP TO PERPENDICULAR POSITION

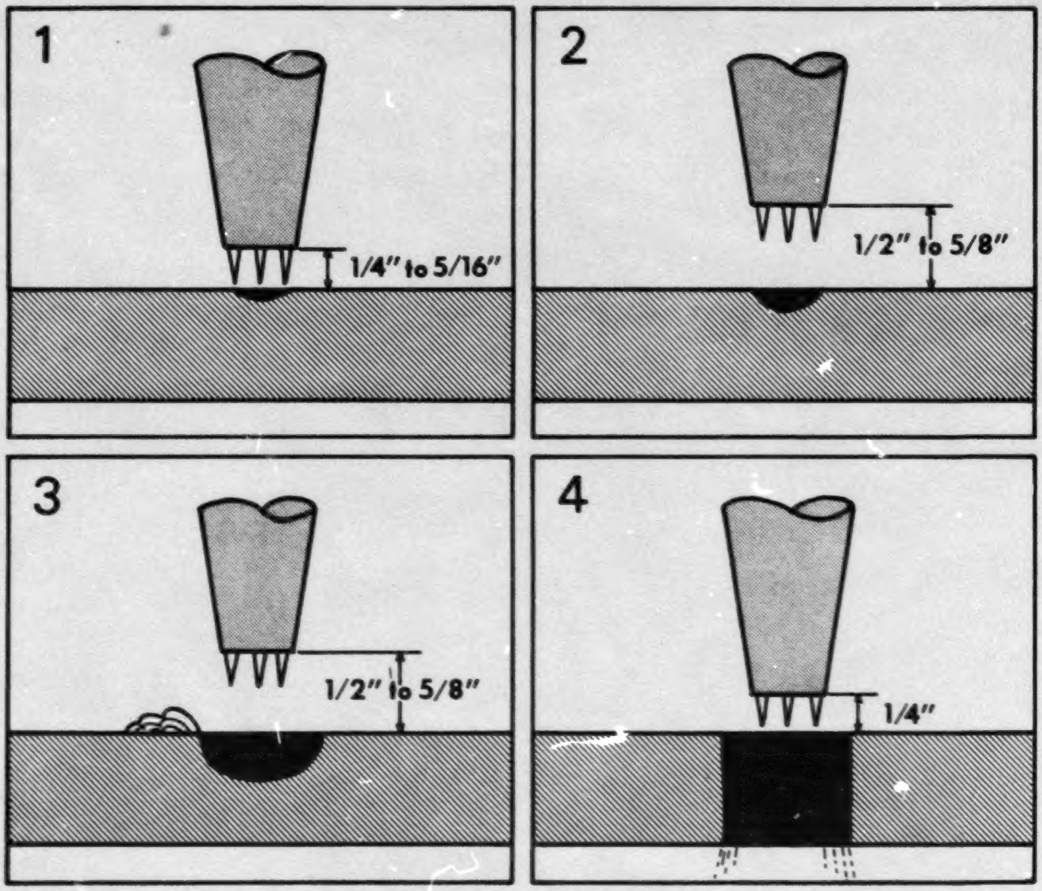


PRESS OXYGEN LEVER FOR CUTTING

CUTTING METAL

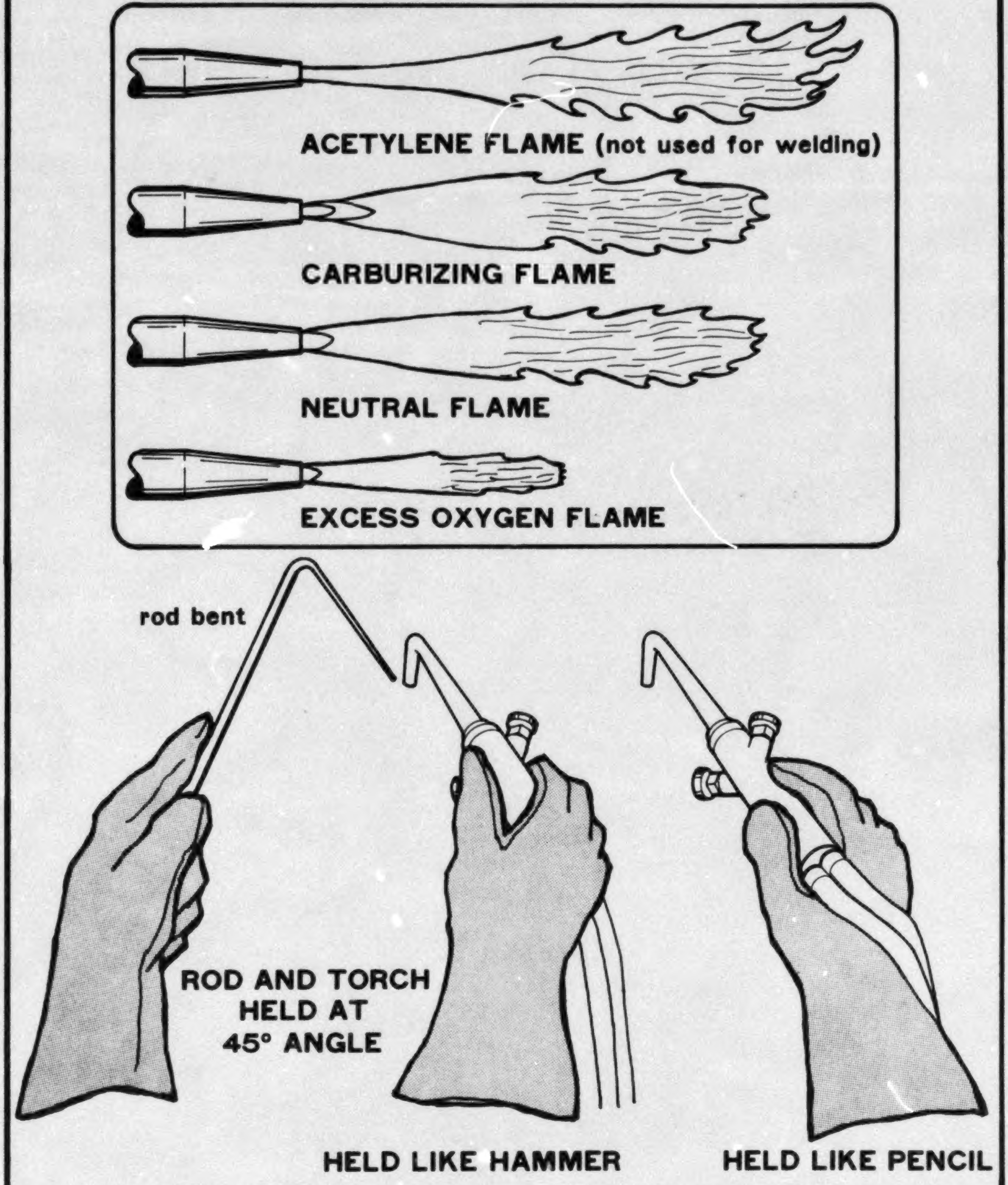

start cut
at 45°
make cut
at 75°

CUTTING CAST IRON

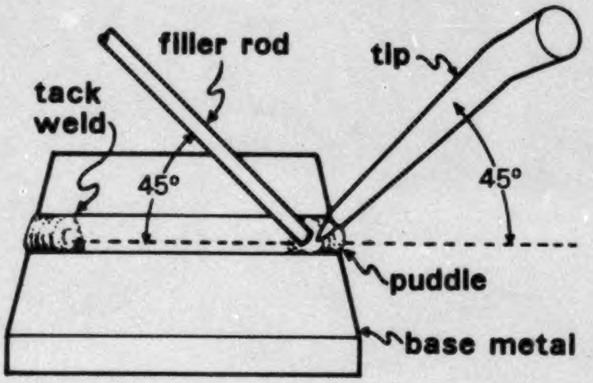

1
1/4" to 5/16"
2
1/2" to 5/8"
3
1/2" to 5/8"
4
1/4"

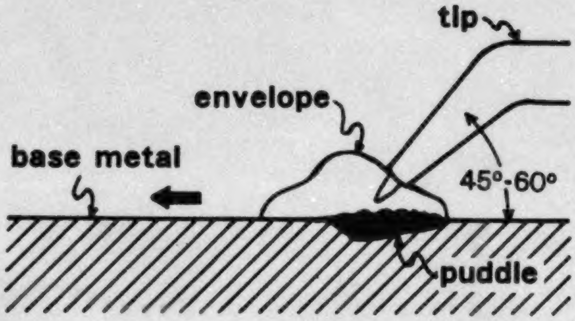
PIERCING HOLE

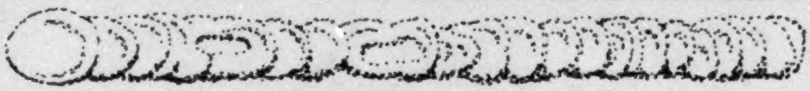
KINDS OF WELDING FLAMES AND TORCH POSITIONS


ACETYLENE FLAME (not used for welding)
CARBURIZING FLAME
NEUTRAL FLAME
EXCESS OXYGEN FLAME
rod bent
ROD AND TORCH HELD AT 45° ANGLE
HELD LIKE HAMMER
HELD LIKE PENCIL

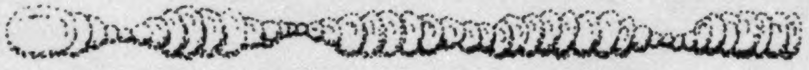
WELDING PROCEDURES


filler rod
tip
tack weld
45°
45°
puddle
base metal

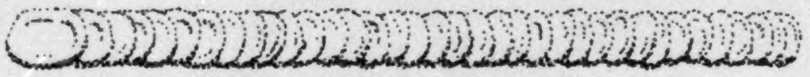

tip
envelope
base metal
45°-60°
puddle



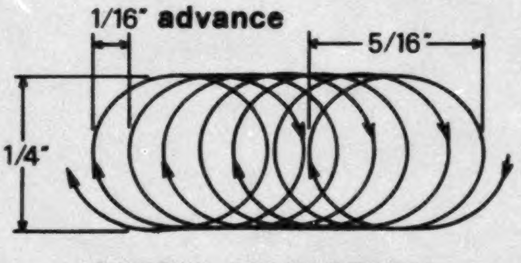
SLOW SPEED - POOR WELD



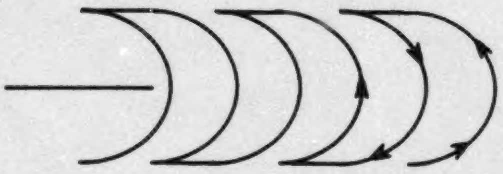
FAST SPEED - POOR WELD



CORRECT SPEED - GOOD WELD

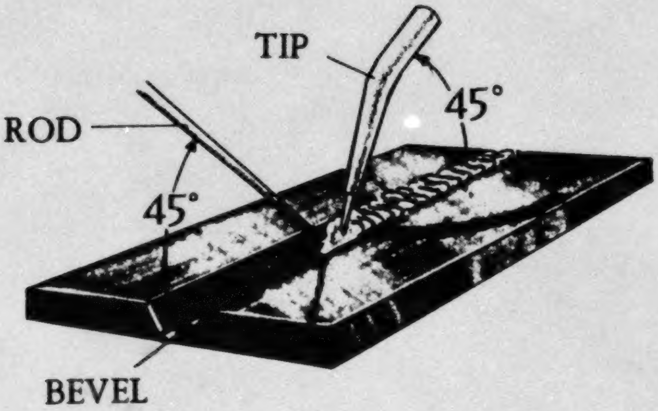

1/16" advance
5/16"
1/4"

CIRCULAR MOTION

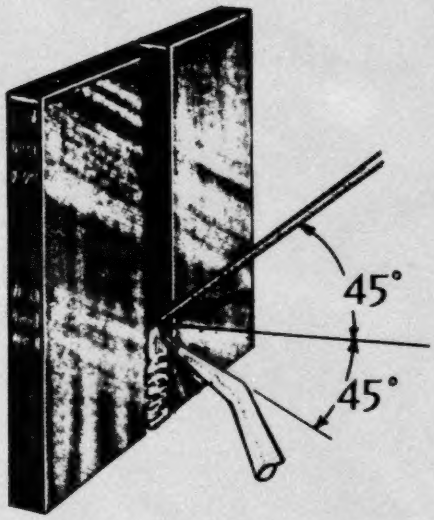


ZIGZAG MOTION

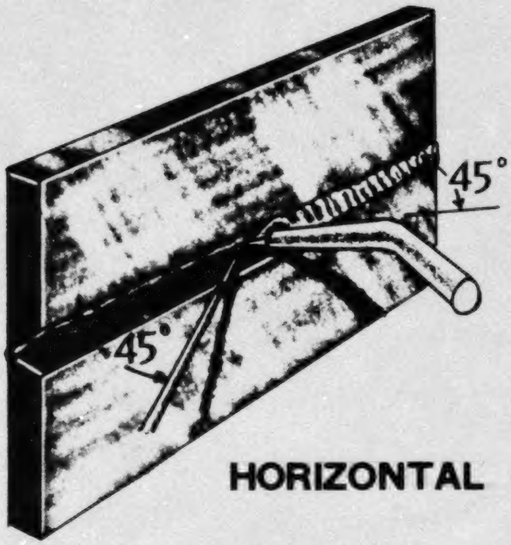
OXYACETYLENE WELDING POSITIONS


TIP
45°
ROD
45°
BEVEL

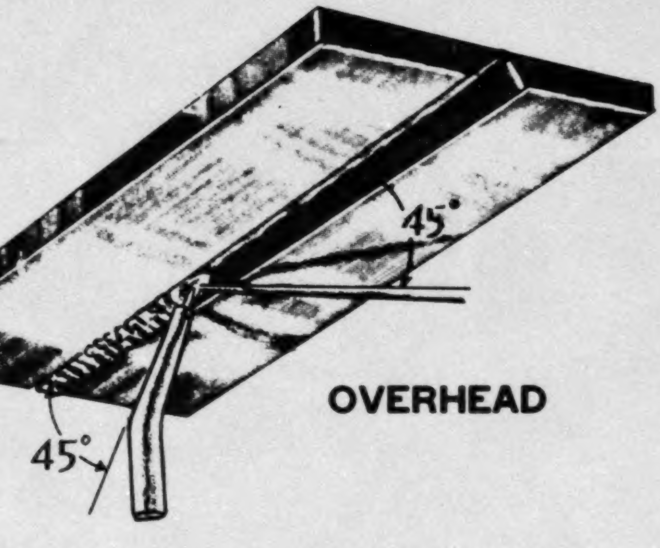
FLAT



VERTICAL

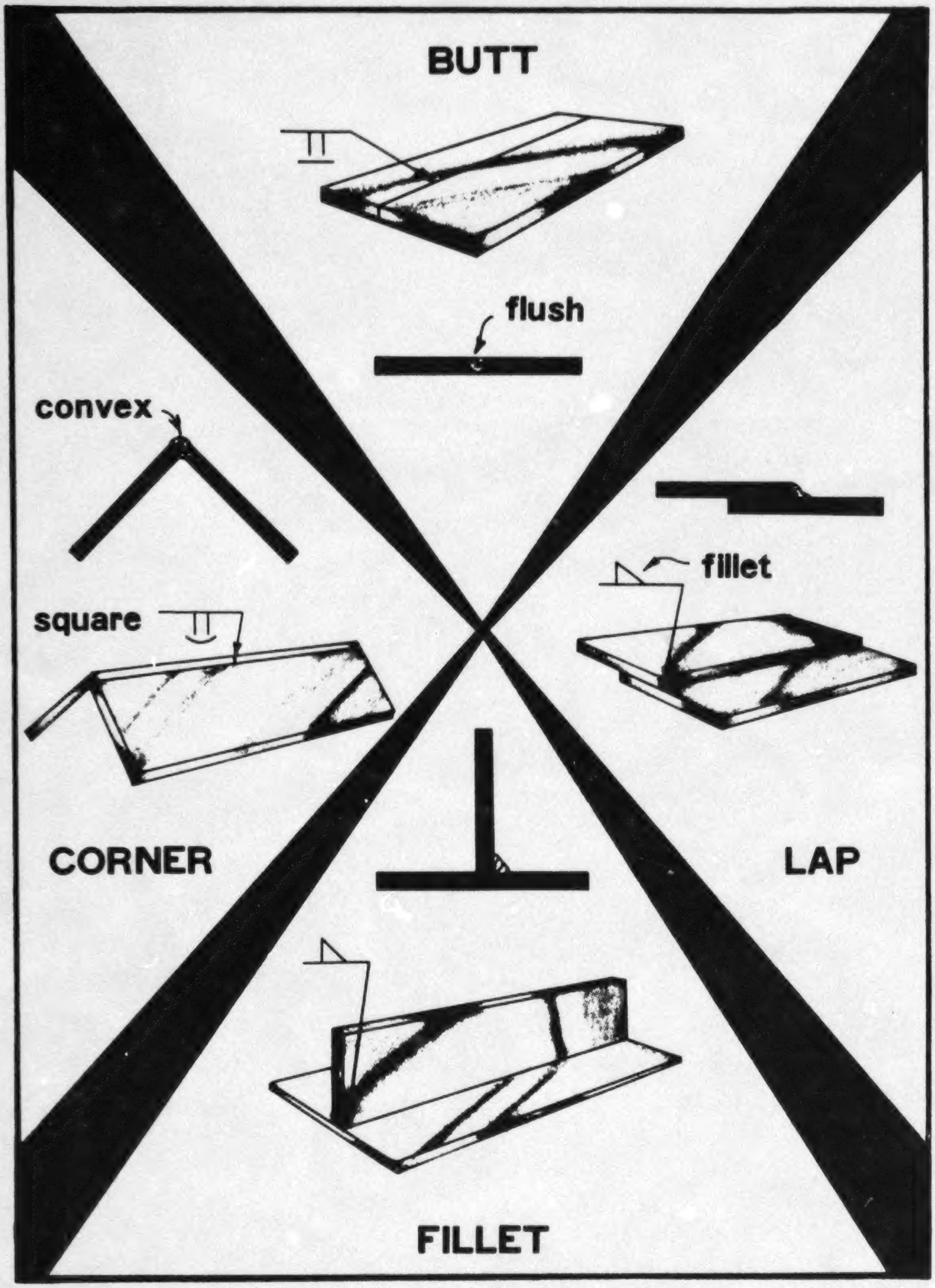


HORIZONTAL

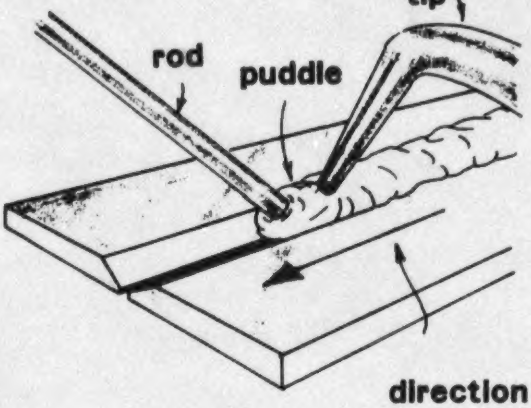


OVERHEAD

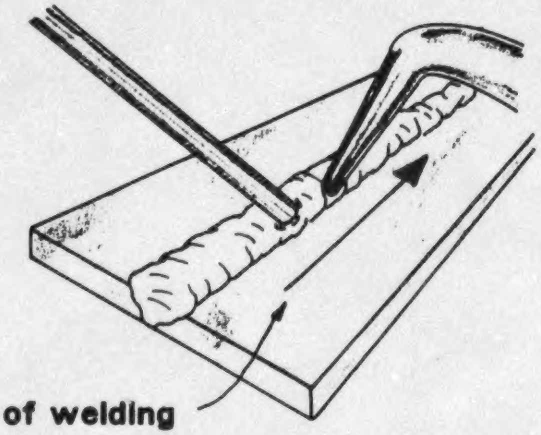
TYPES OF WELDS AND SYMBOLS


BUTT
flush
convex
square
fillet
CORNER
LAP
FILLET

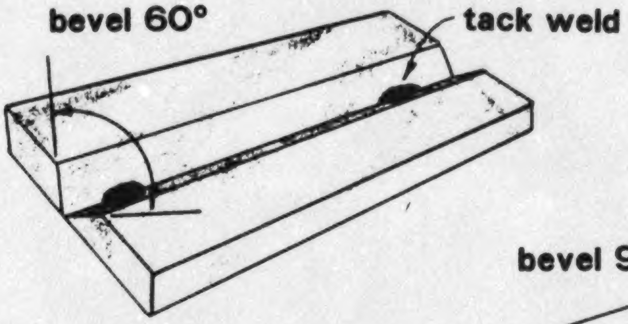
WELDING POSITIONS


tip
rod
puddle
direction of welding

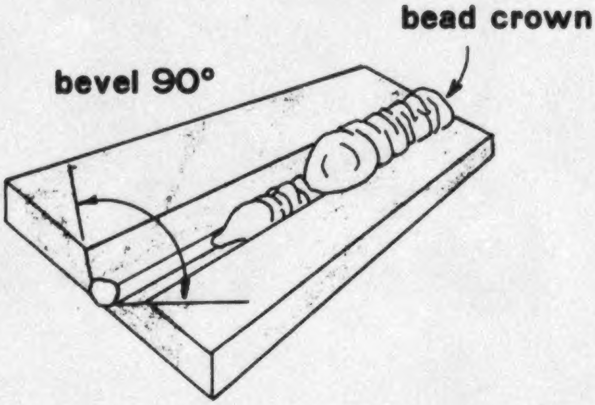
FOREHAND WELD



BACKHAND WELD

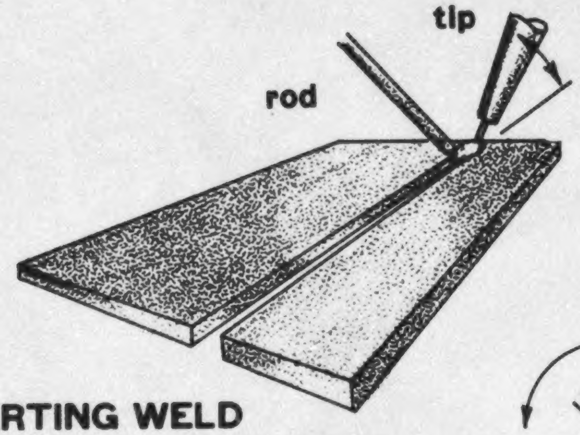

bevel 60°
tack weld

BACKHAND WELD BEVEL

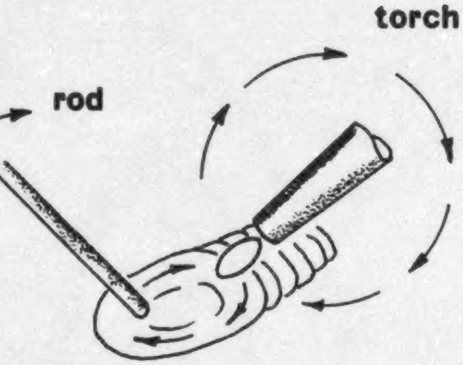

bead crown
bevel 90°

FOREHAND WELD BEVEL MULTI-PASS

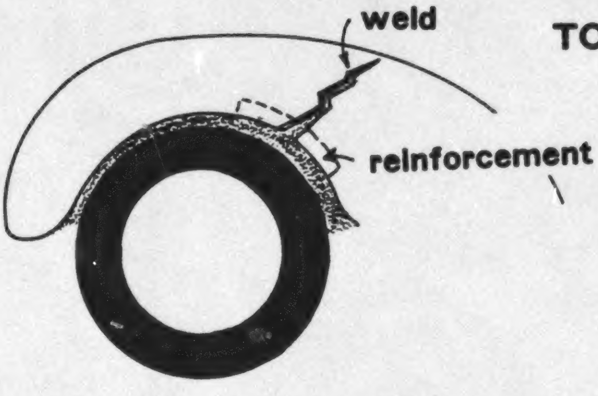
WELDING STEEL



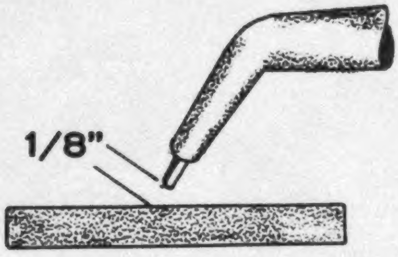
STARTING WELD



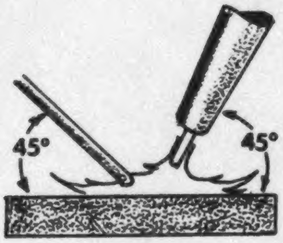
TORCH & ROD MOVEMENT


weld
reinforcement

REINFORCING THIN METAL

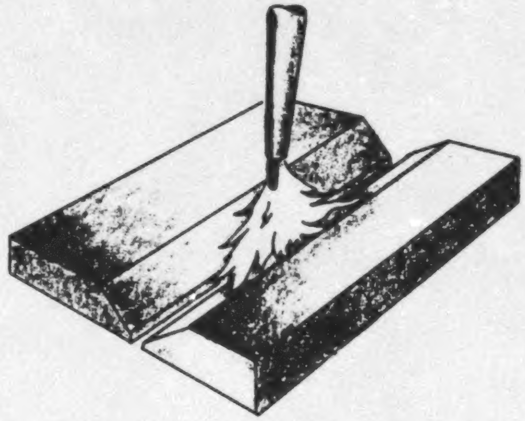


DISTANCE OF CONE FROM METAL

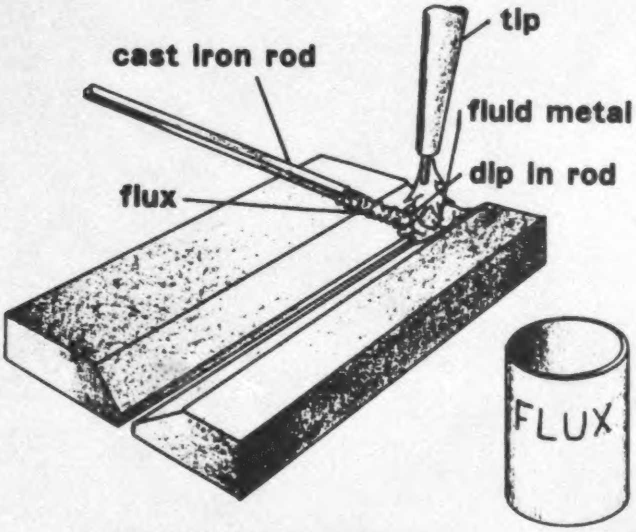


ROD IN OUTER FLAME

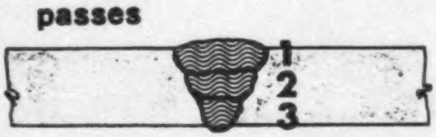
WELDING CAST IRON



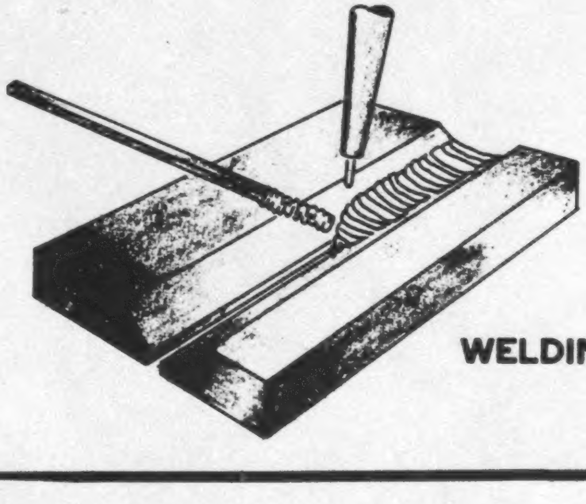
PREHEAT CAST IRON


tip
cast iron rod
fluid metal
dip in rod
flux
FLUX

BEGINNING WELD

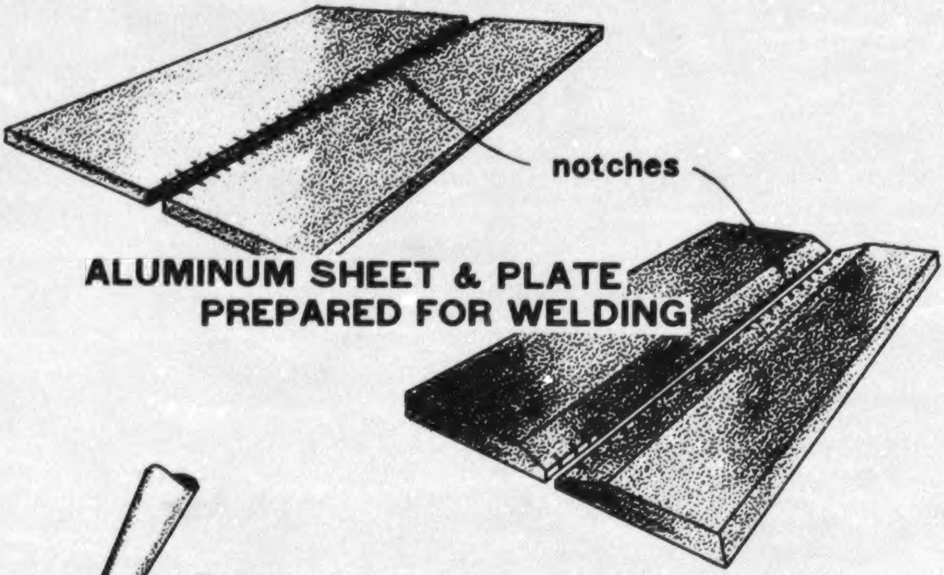


MULTIPLE PASS WELD

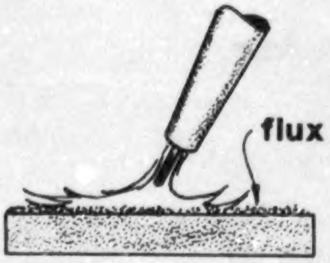


WELDING FIRST PASS

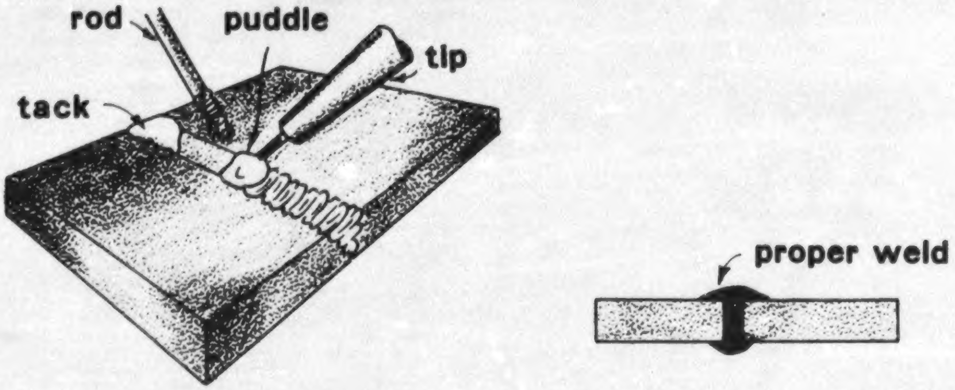
ALUMINUM AND BRONZE



ALUMINUM SHEET & PLATE PREPARED FOR WELDING



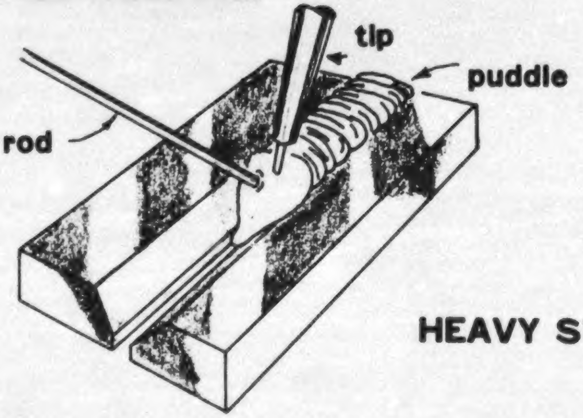
MELTING FLUX ON ALUMINUM

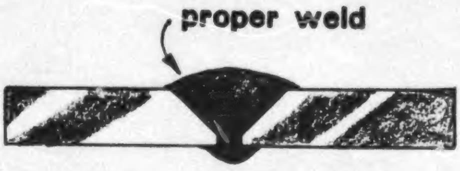

rod
puddle
tip
tack
proper weld

BRONZE WELDING SHEET STEEL

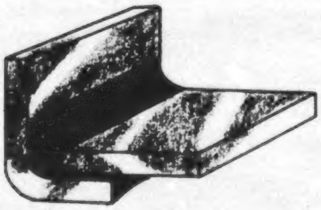
BRONZE WELDING

BRONZE WELDING:

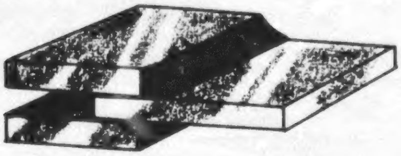

tip
puddle
rod


proper weld

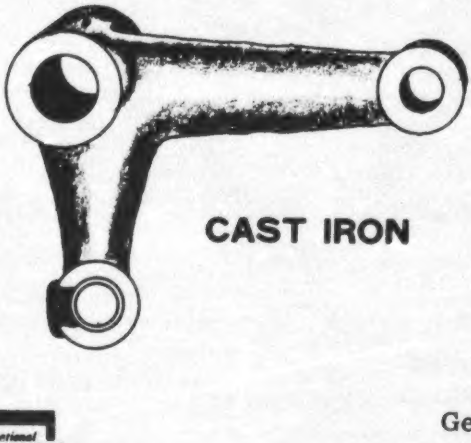
HEAVY STEEL



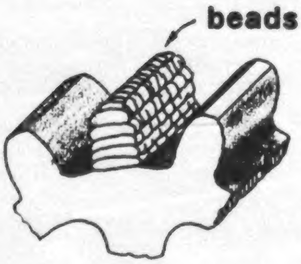
FLANGED BOTTOM



DOUBLE LAP



CAST IRON



TOOTH IN GEAR